LIBRARY
OF THE
UNIVERSITY of ILLINOIS

SCIENTIFIC AMERICAN

SUPPLEMENT, No. 1767

Entered at the Post Office of New York, N. Y., as Second Class Matter.

Copyright, 1909, by Munn & Co., Inc.

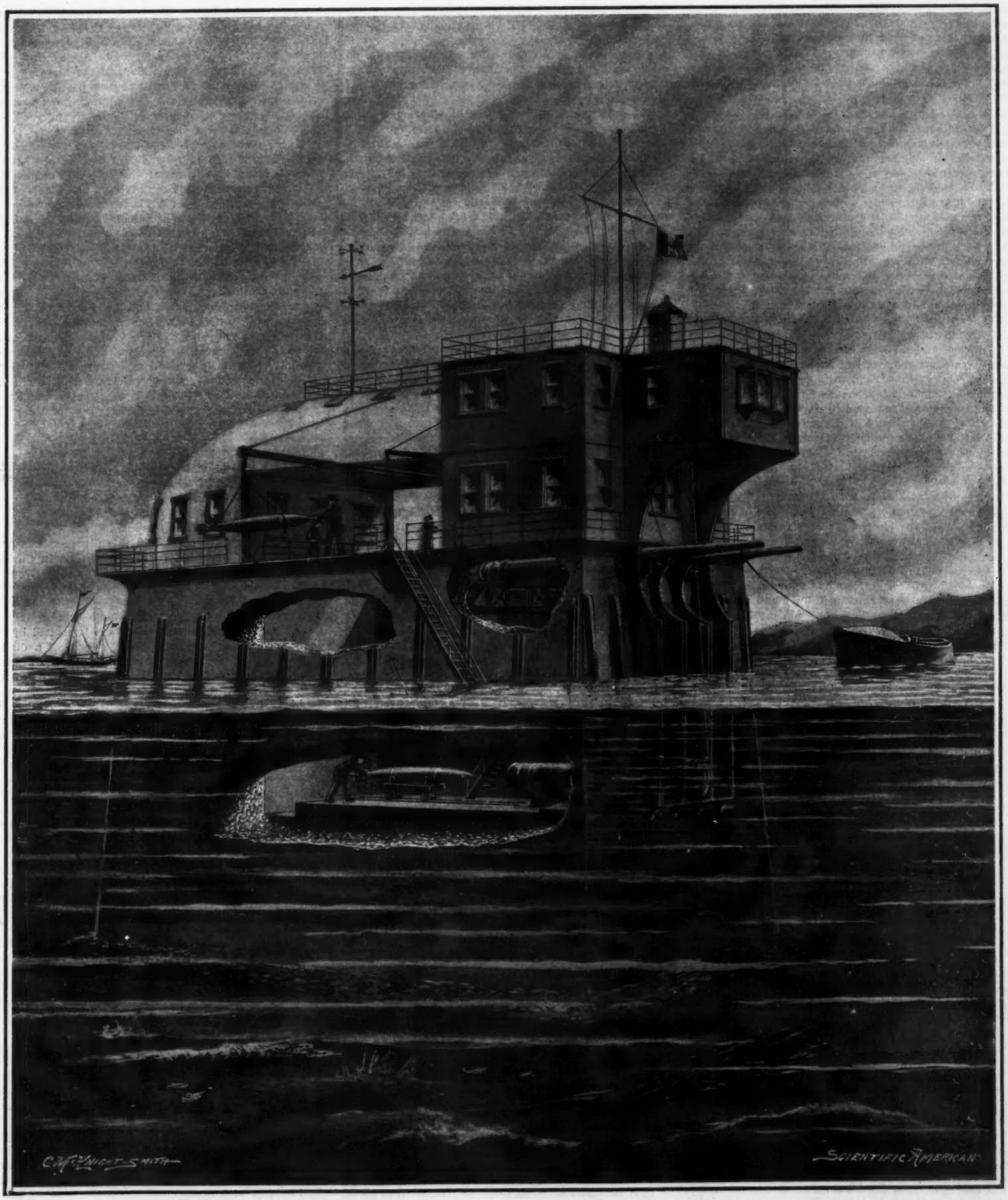
Published weekly by Munn & Co., Inc., at 361 Broadway, New York.

Charles Allen Munn, President, 361 Broadway, New York.
Frederick Converse Beach, Sec'y and Treas., 361 Broadway, New York.

Scientific American, established 1845.
Scientific American Supplement, Vol. LXVIII., No. 1767.

NEW YORK. NOVEMBER 13. 1909.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.



THE SCHNEIDER TORPEDO-TESTING STATION IN THE MEDITERRANEAN.—[See page 308.]

UTILIZATION OF ATMOSPHERIC NITROGEN.*

WHAT IT MEANS TO THE FARMER.

BY A. BERNTHSEN.†

Of the two chief constituents of the atmosphere, we have hitherto been accustomed to look upon oxygen as the fundamentally important element. We are compelled to breathe it in order to support life; it is indispensable to almost every process of heating and combustion, and in the form of oxides, salts, and the like it constitutes nearly one-half of the earth's crust. Nitrogen, on the other hand, we regard as a gas which will not support combustion, and it is generally characterized by a great disinclination to enter into chemical reaction. In spite of this, however, compounds of nitrogen play such an important part in the nutrition of all living organisms, that the task of finding out and opening up new sources of nitrogen compounds has become one of the most interesting and pressing problems of the day.

METHODS OF FIXING ATMOSPHERIC NITROGEN.

The different methods employed in the fixation of atmospheric nitrogen can be divided into three groups: First, the direct formation of ammonia from its elements, nitrogen and hydrogen, both of which have to be isolated for the purpose; second, those processes in which the nitrogen is isolated, and then converted into metallic nitrides and cyanogen compounds, which, in their turn, can be subjected to chemical reaction, and lead to the production of ammonia; and, third, methods which aim at the direct oxidation of atmospheric nitrogen, and the conversion thereof into nitrates and the like. In this last case the air itself is used directly, and a previous isolation of the nitrogen is unnecessary.

It is not difficult nowadays to obtain nitrogen from the air; several methods can be employed on a large scale. One method consists in passing the air over red-hot copper, which retains the oxygen, forming copper oxide. This latter has to be reduced again by passing generator gas over it, and it is then able to absorb a fresh quantity of oxygen from the air. An alternative method consists in liquefying air according to Linde's process, and then separating the nitrogen from the oxygen by fractional distillation. Such processes, however, always increase the cost of the total operation. Hydrogen can also be obtained without great difficulty, since it results as a by-product, for instance, during the electrolysis of potassium and sodium chloride, but here again its cost depends upon the price which can be obtained for the other products of the electrolysis, namely, chlorine and the alkali.

Considering the direct combination of nitrogen and hydrogen, we are at once met by great difficulties, since, at the high temperature at which the combination takes place, the reverse reaction also sets in, and the ammonia formed is to a great extent decomposed back again into its elements. Consequently only a small fraction of the gases can be converted into ammonia, while the rest remains unchanged.

SECOND GROUP OF METHODS.

The second group of methods of fixing atmospheric nitrogen depends on the property of nitrogen of combining with certain metals to form nitrides, or with metals and carbon to form cyanogen compounds, either simple or complicated. These nitrides and cyanogen compounds are then made to undergo a further chemical reaction, produce ammonia and metallic oxides and carbonic acid or other carbon derivatives. These methods consequently bring about an indirect synthesis of ammonia from its elements. The intermediate products formed during the reaction are sometimes of such importance that they are manufactured in this manner, without being finally worked up for ammonia. This is particularly true of the cyanides, especially potassium cyanide, which is used in great quantities in the extraction of gold from its ores.

Frank, in Berlin, and Nikodemus Caro, in Lodz, working in collaboration with Rothe, in Hamburg, noticed that when nitrogen was made to react with carbon and barium carbonate or with barium carbide, some barium cyanide was formed, but at the same time large quantities of another body were obtained, which differed from barium cyanide in containing a smaller proportion of carbon. This body is barium cyanamide. The matter was then taken up by the Cyanid-Gesellschaft, which was formed for this purpose by Siemens & Halske, the Deutsche Gold- und Silber-Scheide-Anstalt and Dr. Frank. Pfleger had suggested that the barium carbide be replaced by calcium carbide, which can be so easily obtained by heating lime and charcoal in an electric furnace. On carrying out this suggestion, a raw product was obtained that contained no calcium cyanide at all, but consisted chiefly of calcium cyanamide, mixed with graphite carbon; it contained lime and carbon as impurities, was black in appearance and had an unpleasant odor, but the chief point was that it contained 20 per cent of fixed nitrogen. The preliminary production of calcium carbide was subsequently found to be unnecessary, a mixture of lime and carbon being substituted. The product is now generally known by the name "Kalkstickstoff" or nitrolime. A similar product, "Stickstoffkalk," was obtained by Polszenius by carrying out the process in the presence of small quantities of calcium chloride, which had the effect of causing the reaction to take place at a lower temperature. Certain other salts possess a similar influence.

The cyanamides, on being treated with superheated steam, are split up with the formation of ammonia, and so this constitutes another process for the indirect synthesis of this compound. Kalkstickstoff or nitrolime has other uses. After being applied to the ground as a manure it is acted upon by bacteria and the like, giving rise to ammonia, and consequently must be applied to the soil before the seed is sown. According to published researches it can only be used on heavy absorbent soils. It also produces different effects on the various classes of plants, and Wagner has come to the conclusion that the farmer should not pay for the nitrogen contained therein more than 80 per cent of the price paid for an equal weight of nitrogen in the shape of Chile saltpeter, or in the saltpeter obtained from the air.

Great hopes have been laid on the further development of these processes, and an industrious agitation has led to quite a number of companies being floated; most of the factories though are still in the state of construction. It is interesting to learn that at Piano d'Orta, at the first nitrolime factory erected, a plant has already been put down for converting it into ammonium sulphate, instead of using it as manure, and, according to recent reports, other works are following this example.

THIRD METHOD OF COMBINING NITROGEN.

The third method of bringing nitrogen into a state of combination, suitable for use on a practical scale, consists of converting it by direct oxidation into oxides of nitrogen, which are then transformed into nitric acid and nitrates. Although, as mentioned before, nitrogen shows little tendency to enter into chemical reaction, it can, under certain conditions, be made to combine with oxygen. The first compound formed is nitric oxide, NO, a colorless gas. On mixing it with oxygen or air, it assumes a yellowish red color, owing to the formation of a higher oxide of nitrogen, which is termed nitrogen teroxide, or nitrogen peroxide, and which possesses a constitution corresponding to the formulas NO_2 or N_2O_4. This is then converted into nitric acid, or into some other form suitable for practical purposes.

The direct combination of nitrogen and oxygen is brought about by means of high temperature, but the degree of combination is limited by the fact that the same temperature which brings about the formation of nitric oxide also tends to decompose it back again into its components. Only at a temperature under 1,200 deg. C. is nitric oxide stable against the action of heat, but at this temperature the amount formed is exceedingly small. Even at 1,500 deg. C., only 1/10 per cent of the nitrogen in the air is converted into nitric oxide, and a very much higher temperature is necessary to bring about a reasonable degree of oxidation. Muthmann and Hofer, and especially Nernst and his pupils, have found that at a temperature of 2,200 deg. C. the gases contain 1 per cent of nitric oxide, at 2,571 deg. C. they contain 2 per cent, at 2,854 deg. C. they contain 3 per cent, and at 3,327 deg. C. they contain 5 per cent. The equilibrium constant is given by the equation

$$K = \frac{C^2NO}{Co_2.CN_2}$$

From the figures just quoted, it is apparent that, in order to be able to work profitably, the air must be heated to as high a temperature as possible, and then cooled down again with the utmost rapidity, so that as little opportunity as possible is given for the nitric oxide, formed at the high temperature, to decompose back again into its elements.

FUNCTION PERFORMED BY ELECTRICITY.

It is generally accepted that electricity brings about the reaction by means of the high temperature produced, but on the other hand, it is possible that it exercises also a specific electrical action on the gases, for we know that nitric oxide is produced from its elements by the action of silent discharges, as well as by the action of spark discharges and electric arcs. All efforts in this field have been applied to the production of series of sparks of electric arcs, and during the last decade, an intense activity has been developed, both in the laboratory and also on the practical scale.

BRADLEY AND LOVEJOY OPERATION.

One class of scientists started by assuming that in order to use up the electrical energy to the best advantage, it should be distributed over a large number of small sparks or arcs. Bradley and Lovejoy founded their process on this assumption, and the Atmospheric Products Company was floated toward the end of last century, with a capital of one million dollars, and carried out their process at Niagara, making use of power obtained from the falls. They employed iron cylinders about 4½ feet high and 4 feet in diameter. In the axis of each of these a steel shaft rotated, containing, mounted one above the other, 23 zones of electrode arms, each zone containing 6 arms, and each arm being provided with a platinum sparking terminal. The wall of the iron cylinder formed the other electrode, and was provided with a similar number of platinum terminals or poles, situated opposite to the terminals of the rotatable electrode. When the shaft was put into motion, the electrode poles, attached to the ends of the arms, came within sparking distance of the poles on the cylinder, and sparks sprang across from one pole to the other. As the motion of the shaft continued, the electrode poles were separated from one another, and the arc was drawn out and finally snapped, only to be formed again as soon as the next pair of poles came within sparking distance of each other. A direct current of 10,000 volts was employed and no fewer than 414,000 arcs or sparks were formed and extinguished every minute. Air was passed through the cylinder. According to Muthmann, the yield amounted to 430 kilogrammes saltpeter per kilowatt-year, a small yield, which, coupled with the complexity of the apparatus as well as its initial expense and the expense of keeping it in order, sufficed to prevent the process being worked as a profit.

BIRKELAND AND EYDE PROCESS.

The first practical success in this direction was obtained in 1903 by Prof. Kristian Birkeland in Christiania, who worked in collaboration with the Norwegian engineer, Samuel Eyde. It was already known that if an electric arc, fed with an alternating current, be made to burn between the poles of an ordinary magnet, or of an electromagnet which is excited by a direct current, the arc assumes the form of a disk. More correctly, the arc is blown into a half disk at every half period, but the impression on the eye is that of a quietly burning disk, like the sun. Birkeland and Eyde inclosed this in a flat iron-clad furnace of fireproof clay, and passed a strong current of air through it, and they thus obtained considerable yields of oxides of nitrogen.

Since their first experiments, the furnaces have gradually been increased in size, until those now used are so large that each of them is fed with 700 kilowatts at a tension of 5,000 volts, and the disk of flame is over 2 yards in diameter. Each furnace uses up nearly 1,000 horse-power, that is, 100 times as much as those of the Atmospheric Products Company. The utilization of this large quantity of electricity in a single discharge constitutes the great difference between Birkeland and Eyde's process and those of the earlier experimenters.

METHOD OF OTTO SCHÖNHERR.

The great importance attaching to the possibility of fixation of atmospheric nitrogen had, several years before that time, been recognized in the Badische Anilin- u. Soda-Fabrik, and special attention was paid to this new problem. As the result, Otto Schönherr succeeded, in 1905, in discovering, and with the assistance of the engineer Hessberger, working out a process of producing an electric arc, and was thus enabled to solve the problem in a surprisingly simple manner, presenting considerable advantages over the method of Birkeland and Eyde. It is not a mere modification of their process, as has sometimes been falsely assumed, but differs fundamentally from it. Schönherr dispenses entirely with magnets and magnetic fields, and produces his arc inside an iron tube of comparatively small diameter, at the same time passing the air through the tube, and thus bringing it into contact with the arc.

The manner in which the arc is developed is in itself very peculiar and interesting. The iron tube,

* Abstract of an address delivered at the Seventh International Congress of Applied Chemistry, London, 1909. From Jour. Ind. and Eng. Chem., p. 466, July, 1909.

† Director of the Badische Anilin- u. Soda-Fabrik, Ludwigshafen a/Rh

or arc tube, contains an insulated electrode at one end, and can itself serve as the second electrode. The arc, at its formation, springs from the insulated electrode to an adjacent part of the arc tube which is only a few millimeters away, but the air, which is passing through the tube, being preferably introduced with a tangential or rotary motion, immediately carries the end of the arc along the wall of the tube, so that it either enters the tube at a considerable distance from the electrode, or it ends on a special electrode placed for the purpose, say, at the other end of the arc tube. A column of flame is obtained, burning quietly in the axis of the tube, and surrounded by the air which is being passed through the tube. The arc emits an intense light, and is quite stable. The air passing through the tube comes into contact with the arc, becomes partially converted into nitric oxide, and is then rapidly cooled down by contact with the outside layers of air, and consequently a decomposition back again to nitrogen and oxygen is avoided. The cooling action is still further increased by surrounding the upper end of the arc tube with running water, after the manner of the Liebig condenser. The gases leaving the tube contain about 2 per cent of nitric oxide, that is, from one and a half times to nearly twice as concentrated as the gases which Birkeland and Eyde produce. The method of introducing the air can be subjected to many variations.

With the aid of Schönherr's invention, it is possible to send extraordinarily large quantities of electrical energy through a single tube. The experimental furnaces at Christiansand are fed with about 600 horsepower at 4,200 volts, and although it appears possible to build furnaces which could consume 2,000 horsepower, those regularly used will probably be built for 1,000 horse-power. These furnaces require about 40,000 cubic feet of air every hour, and the arcs produced are nearly 8 yards long.

CONSTRUCTION OF SCHÖNHERR APPARATUS.

In the furnace on the large scale, the air passes into the arc tube through a number of tangentially bored holes in the part of the tube surrounding the electrode, and over these holes is an iron ring or cylinder, which can be moved from the outside by means of a lever, so that any desired number of the holes can be closed, and the strength of the rotary motion of the air regulated; this in turn assists in regulating the length of the arc. The insulated electrode can be cooled by means of water or air, and it is also provided with a central hollow space through which passes an iron rod. The arc actually springs from this iron rod, and as it burns or volatilizes away, it can be pushed forward by a simple arrangement; the rate of burning, however, is very slow. An ignition lever, or other simple arrangement, is provided so that the arc can be started afresh, if necessary. The furnace itself is connected electrically to earth, so that any part of the apparatus, with the exception of the insulated electrode, can be handled with impunity. The gases which leave the arc tube pass down a channel lined with brick, and concentrically surrounding the inner parts of the furnace. They are thus made to give up a portion of their heat to the air which is entering the furnace, and which is subsequently passed through the arc tube, thereby raising it to a fairly high temperature. This apparatus is extremely simple and durable; ordinary iron tubes are employed; there are no movable parts and no expensive electromagnets, and the manufacture runs smoothly without interruptions.

Though in this process there is very little loss of electrical energy in producing the arc, yet only a few per cent of the energy serve to bring about chemical reaction; the rest is converted into heat. This latter, however, is not by any means wasted; 30 per cent of it is employed producing hot water, 40 per cent heats the boilers, 10 per cent has to be removed by cooling, and only 17 per cent is lost by radiation. The evaporation of the calcium nitrate solutions obtained is carried out solely by the heat generated in the arc. Another process worked by Pauling and utilized near Innsbruck by the Salpetersäure-Industrie-Gesellschaft of Gelsenkirchen depends on the use of divergent electrodes. From the data given by the author the process is inferior to the Badische process.

COMMERCIAL FEATURES OF PROCESS.

After the nitrogen has been converted into nitric oxide, according to any of the processes referred to, the actual combustion of the nitrogen is completed, but on cooling the reaction gases, as soon as the temperature reaches a certain point lying at about 600 deg. C., the nitric oxide begins to combine with the excess of oxygen, forming nitrogen tetroxide. The oxidation does not go past this stage of its own accord.

The next task is to bring these oxides of nitrogen into a marketable state, that is, either into the form of nitric acid, nitrates, or nitrites; also nitrogen tetroxide as such will be capable of isolation.

Up to the present time both nitric acid and nitrites have been manufactured from saltpeter by chemical reaction, nitric acid being produced by heating saltpeter with concentrated sulphuric acid, while nitrites result on heating sodium nitrate with metallic lead, which extracts one atom of oxygen, and is itself converted into lead oxide. Both nitric acid and nitrites are consequently more expensive than saltpeter. Nitrogen in concentrated nitric acid is two and a half times, and that in nitrites is one and a half times as valuable as nitrate-nitrogen.

ACID ABSORPTION PROCESS.

It would, therefore, be more profitable to make nitric acid and nitrites, provided the consumption of these compounds were sufficiently great; but since the demand is limited, the chief aim of every large factory is to convert the supply of nitrogen into the form of saltpeter, for which there is an unlimited market. Before the nitrogen tetroxide contained in the furnace gases, after they have been cooled, is capable of yielding nitric acid, it requires to be combined with a further atom of oxygen, and this combination is generally brought about by the action of water. The gases are passed through an absorption tower down which water is trickling, and during the reaction which takes place, two-thirds of the nitrogen is converted into nitric acid, while one-third is regenerated as nitric oxide, which combines again with the excess of oxygen present in the gases forming nitrogen tetroxide, and this goes through the same course of reactions again. This constitutes the so-called acid-absorption process. The absorbing liquid can be run down the tower several times, each time becoming richer in nitric acid, until a 40 per cent acid is obtained. (This must be further concentrated before it is marketable.) On neutralizing this acid with soda, a concentrated solution of sodium nitrate is obtained, and can be evaporated until the solid salt crystallizes out. On a practical scale, however, ordinary limestone is employed instead of soda, and calcium nitrate is obtained. This is at least as valuable as sodium nitrate for manuring purposes, and is consequently isolated as such, and brought on the market under the name of Norwegian or air saltpeter.

OTHER CONVERSION METHODS.

Nitrates can be obtained directly from the furnace gases, by employing sodium carbonate or milk of lime as the absorbing agent, and at the same time maintaining the temperature and other conditions, such that, during the absorption, the gases contain equal quantities of nitrogen tetroxide and unaltered nitric oxide. According to this process, the Badische Anilin- u. Soda-Fabrik manufacture, at Christiansand, the sodium nitrite they require in their dye factory at Ludwigshafen.

Finally, if the reaction gases be cooled down to a temperature considerably below zero, nitrogen tetroxide separates out as a liquid, or, if the temperature be sufficiently low, it can even be obtained in the solid state, like ice of snow. Should the gases contain moisture, more or less dilute nitric acid is produced, the quantity depending on the amount of water present.

A further method of working up the furnace gases consists in passing them over quicklime. Halvorsen carried out this process at ordinary temperature, while Schloesing obtained better results by working at a raised temperature. The latter employs briquets of quicklime, prepared by molding slaked lime into the required shape, and then reheating it, and he places these briquets in iron vessels, and heats them on the counter-current principle, by means of the furnace gases, to from 300 to 350 deg. The final product of absorption contains dry calcium nitrate in admixture with free lime, and some calcium nitrate.

The absorption at Notodden is at present carried out according to the acid process; the first product is dilute nitric acid, which is subsequently converted into calcium nitrate. In order to recover the oxides of nitrogen which remain unabsorbed, the gases are finally treated with milk of lime or soda, and give rise either to a mixture of nitrite and nitrate, or to pure nitrite. More recent experiments at the Badische Anilin- u. Soda-Fabrik have shown the possibility of effecting the absorption directly with milk of lime, and in this case the acid absorption would be dispensed with and the initial outlay on plant greatly reduced.

UTILITY OF PRODUCT.

The calcium nitrate, obtained by means of the operations described, can, without further treatment, replace Chile saltpeter for the purposes of agriculture. Even a certain quantity of free lime, say 20 per cent, appears to have no deleterious action on vegetable life, and the same remark applies to any calcium nitrite mixed with the nitrate. It is conceivable that calcium nitrite will become the artificial manure of the future, especially as its manufacture is so simple, and it is richer in nitrogen than calcium nitrate (it contains 21.2 per cent of nitrogen). It possesses the further advantage of being less hygroscopic than calcium nitrate.

PLANTS IN CONSTRUCTION AND OPERATION.

Both the process of the Badische Anilin- u. Soda-Fabrik and of Birkeland and Eyde require cheap water power, before they can be carried out profitably. The waterfalls in Norway, which, owing to the climate, have a fairly constant supply throughout the year, are particularly suitable. The Badische Anilin- u. Soda-Fabrik secured the right of using several falls there, and commenced by putting down an experimental plant at Fiskaa near Christiansand. A few thousand horse-power were available, and the manufacture was started in the autumn of 1907.

In the meantime the Norsk Hydro Elektrisk Kvaelstof-Aktieselskab, that is, the Norwegian-French Company founded by Birkeland and Eyde, has commenced building a factory at Notodden to use up 30,000 horse-power. Finally, toward the end of 1906, the Badische Anilin- u. Soda-Fabrik and its two allied firms, the Farbenfabriken vorm. Friedr. Bayer & Co., of Elberfeld, and the Actiengeselischaft für Anilinfabrikation, in Berlin, on the one side, and the Norwegian-French concern on the other side, combined forces and f ated two new Norwegian companies. These were: (1) A power company with a capital of 16,000,000 kronen, whose duty it is to develop and bring into harness further Norwegian waterfalls, and (2) the Norsk Salpeterverker with a capital of 18,000,000 kronen, which is concerned in building and running Norwegian saltpeter factories, making use of the power supplied by the first company. The two parties have come to an arrangement as to the exploitation of their patents outside Norway, and the granting of licenses lies in the hands of the Badische Anilin- u. Soda-Fabrik. The works at Christiansand and Notodden remain the special property of the original owners.

The first large factory erected by the new Norwegian companies will be situated in the interior of Telemarken on the Rjukan, one of those immense waterfalls in Norway. The total fall of 1,820 feet is divided into two steps, and with a flow of about 11,000 gallons of water per second is capable of yielding a quarter of a million horse-power. The upper fall is now being developed, and with 10 turbines will provide about 140,000 horse-power. It is expected that the factory will start running in about two years' time. The saltpeter will be carried along 29 miles of standard-gage railway, and by a ferry along Lake Tin, which is 25 miles in length, until it reaches Notodden; from here it will be transported *via* Skien to the sea. At present the Norsk Hydro Kvaelstof-Aktieselskab is using up 30,000 horse-power at its factory at Notodden, where 35 of Birkeland's furnaces have been erected, and at the present time an experimental plant on the system of the Badische Anilin- u. Soda-Fabrik is being constructed there, in order to determine which type and size of furnace is most suitable for erection at Rjukan. Water power on the Matre and on the Tin in West Norway have been acquired, and will be held in reserve for future use.

In Germany the water power suitable for the production of saltpeter is very limited. In South Bavaria the Alz is able to supply sufficient power for a moderately large factory, and negotiations have already taken place with the Bavarian government with regard to a scheme for the production of 50,000 horse-power and the erection of a factory near Burkhausen. Negotiations have also been going on for some time with a view to the introduction of the manufacture into this country, but here also suitable water power is hard to find.

NITROLIME OR AIR-SALTPETER.

The production of air-saltpeter requires, in addition to electrical power, only the very cheapest materials, namely, water and limestone, whereas, in order to produce nitrolime coal has to be employed, and, in addition, the nitrogen used in the process cannot be taken in the form of air, but first must be separated from the oxygen. Moreover, there are other points in favor of the production of air-saltpeter. Not only has the nitrogen contained in it a higher value than that in ammonium sulphate, or in nitrolime, but, by the oxidation of nitrogen, the nitric acid, nitrates and nitrites which are so indispensable in the chemical industry are obtained. These compounds have a higher value than air-saltpeter, the nitrogen in nitric acid being worth more than twice as much as that in ammonia. The prospects of a profitable conversion into nitric acid of the ammonia obtained from nitrolime appear very doubtful.

Another factor which must not be underestimated when considering the advantages of the new air-saltpeter industry, is its non-participation in the destruction of the valuable coal deposits which have been stored up for us during such countless ages. It obtains the power it requires from water, or as it has been fancifully termed, "white coal," which can be employed over and over again without being exhausted. It is significant, too, that for this industry the larger the waterfalls the greater is their usefulness.

We have consequently every reason, from such different points of view as those of the agriculturist, the industrial chemist, and the whole of mankind, to hope that the new process for the cumbustion of nitrogen will continue to develop and flourish.

THE SCHNEIDER TORPEDO-TESTING STATION.*

A NOVEL UNDERTAKING.

MESSRS. SCHNEIDER & Co. have added of late to their specialties the manufacture of automobile torpedoes, and in so doing they have rendered France independent of all outside sources for this type of weapon. They have signed a contract with the French Ministry of Marine for the supply of a number of such torpedoes of 450 millimeters (17.7 inches) in diameter, and they decided to put down on the French sea-coast a proving station, to be used both for regulating these weapons and for carrying out their acceptance tests. After considering all the likely locations round the whole French seaboard, they selected Léoube Bay, which forms a portion of the Hyères roadstead, in the Mediterranean. This met the conditions required for a submarine testing station, as it allowed a free range of at least 5,000 to 6,000 meters (about 6,000 yards), a free width of 200 meters (656 feet) at a distance of 200 meters from the launching-point, and a free width of 500 meters (1,640 feet) at a distance of 400 meters (1,312 feet) from the same point, a mean depth below datum of from 9 to 12 meters (30 feet to 40 feet), clear water and a satisfactory sea bottom, few currents, there being also sufficient shelter against bad weather, and proximity of the site to the coast.

The battery which it was proposed to erect had to fulfill a double purpose in enabling torpedoes to be launched both 3 meters (9 feet 10 inches) above and below the average sea level. To meet this, several solutions were considered. Among these we may mention a metallic open-work platform built on pile work and provided with two submarine launching-tubes and with one aerial spoon-tube, the platform installation being completed by a 300-ton floating workshop to contain the machinery and compressors, stores, offices, etc. This solution was abandoned owing to the high cost involved and to the difficulty of constructing a really effective platform of the kind. Another scheme consisted in sinking a compressed-air caisson at a distance of about 300 yards off the coast, for building the necessary foundations to carry a masonry construction containing a room provided with the necessary machinery and torpedo-launching tubes. The difficulties which surrounded the problem were varied; the exact nature and resistance of the subsoil at the site contemplated were imperfectly known. No tempests and periods of heavy swells such as those which obtain in the Atlantic were to be anticipated; but it was feared, on the other hand, that operations would frequently be delayed by the prevailing winds at that part of the coast, the south and southeast winds and the northwest "mistral." As it happened, these prevailing winds rendered actual operations impossible last winter on the scheme selected for quite two weeks in each month. Working by compressed-air caissons was abandoned as being too risky in itself, and as likely to prove dangerous to the men employed; moreover, the necessary plant and compressors for one caisson only would have worked out at too high a cost.

The scheme which was adopted and followed out on the designs prepared by Mr. Michel-Schmidt, director of the Public Works Department of Messrs. Schneider's establishments, was the construction on a slip of an armored concrete caisson to be towed out to the site, and there sunk on a specially prepared platform on the sea bottom. The preparation of this platform was carefully gone into, and considering the very special nature of the structure to be put down, also its height and comparatively small base, it was decided to dredge the site proposed, so as to insure for the structure a firm foundation. The best machine for the work was found to be the Priestman spoon dredging machine, mounted on a sea-going boat, able, on an emergency, to take advantage of the otherwise not too satisfactory shelter available in Léoube Bay, able also to work during an average swell, and to lift easily blocks, wreckage, etc., which a bucket dredger could not readily deal with.

The problem therefore was to construct a "small island" of armored concrete, sunk to a depth of 12 meters (about 40 feet) below datum, on a platform of stone packing resting on a firm bottom and made perfectly level. The lower portion of the structure has the shape of a pyramid frustum, 15.5 meters (50 feet 10 inches) high. It consists mainly of an armored concrete caisson, the dimensions of which are approximately: Length, 23.5 meters (77 feet); width inside the shoe, 14.8 meters (48 feet 6 inches) at the base, and 21.29 meters (69 feet 10 inches) length, and 11.08 meters (36 feet 4 inches) width at the top, at a height therefore of about 11 feet above the sea level. The outside walls are 150 millimeters (5.9 inches) thick, and are stiffened by small horizontal ribs. The caisson is divided inside into cells by vertical partition walls 100 millimeters (3.9 inches) thick. The lower shoe is curved over 2 inches in transversal section at the center, so as to better insure its anchorage on the platform. The caisson and cells are concreted, as shown in Figs. 1 and 2. The structure thus constituted forms the base of the construction, and affords all guarantee of stability. It is protected on the outside by thirty-eight vertical oak beams provided with mooring rings. It contains a room measuring 14.5 meters by 5.9 meters (47 feet 6 inches by 19 feet 5 inches), provided with three small tracks for serving the torpedo-launching tubes, and with a 2-ton, 7.5 meters (24 feet 7 inches) span overhead traveling crane.

The brass head mountings for the three submarine launching tubes are built in the west wall of the caisson. Their axis is 3 meters (9 feet 10 inches) below sea level (see Figs. 1 and 2). In order to facilitate inspection and maintenance of the mountings, armored concrete brackets made with grooves for taking independent sluice valves have been provided in front of the outside brass sluices, the arrangement thus resulting in three chambers, the exhausting of which is easily carried out by the machinery in the battery. Two aerial launching tubes are located 3 meters (9 feet 10 inches) above sea level, as shown in

FIG. 1.

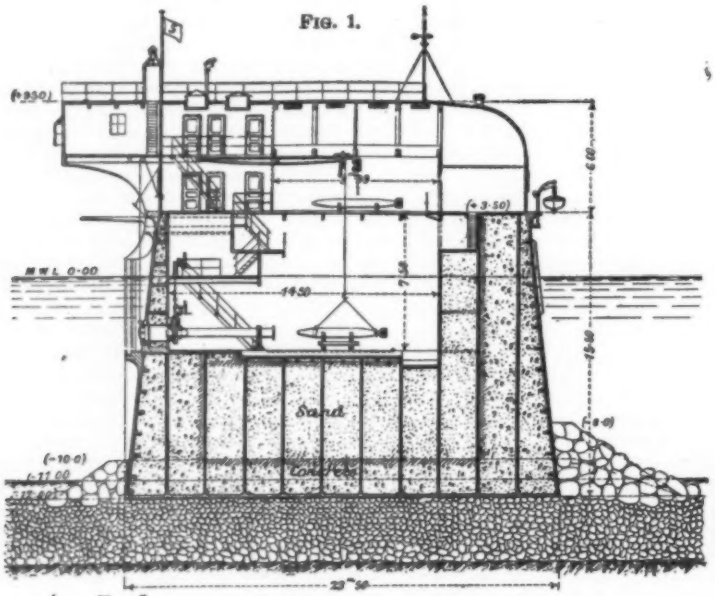
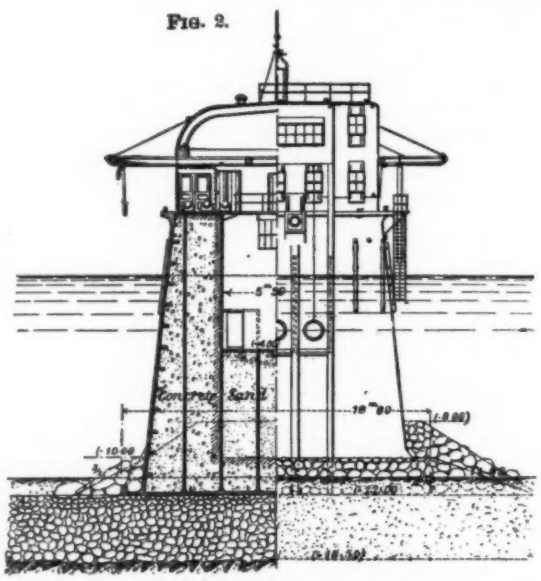


FIG. 2.



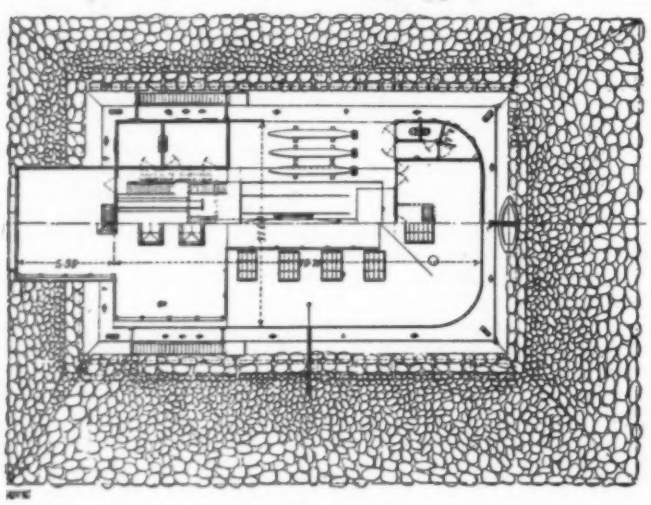


FIG. 3.

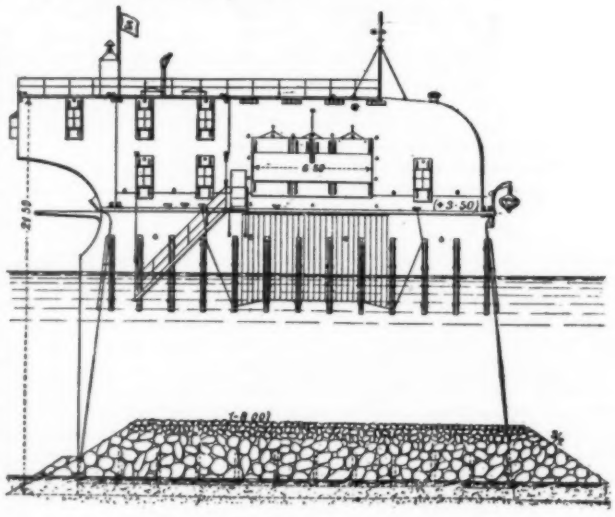


FIG. 4.

THE SCHNEIDER TORPEDO-TESTING STATION IN THE MEDITERRANEAN.

* Engineering.

Figs. 3 and 4. They are mounted inside armored concrete sheaths, closed on the outside by water-tight doors. The battery is divided internally by floorings at different levels, connected together by iron stairways for facilitating operations.

An armored concrete superstructure has been built on the top of the lower portion above referred to, containing the rooms for regulating the torpedoes and for the personnel of the battery. A watch platform has been provided, with a hand-rail anchored in the outside wall of the superstructure. The front of the battery, on the launching side, is in the shape of a parallelopiped, the top of which forms a terrace, in which are provided skylights and ventilating openings. The rear portion is rounded off, and is also provided with skylights and ventilating openings. On the west side are located the observation room and rooms for the men; the room for maneuvering the torpedo is in the center. The engine room is on the east side. As will be seen, the observation room is built overhanging. It has an armored concrete veranda in front, closed in by glazed window frames, and the flooring of which is made of thick glass slabs, to facilitate the taking of observations when firing aerial or under-water torpedoes. An armored concrete cabin built on the terrace serves as a look-out, and carries a searchlight and a mast for signaling.

The room in the center is fitted up to serve as a provisional depot for torpedoes and as a refuge for the vedette boats. It opens out into a bay 9 meters (29 feet 6 inches) wide and 3 meters (9 feet 10 inches) high, on the north side, and into a bay 6.5 meters (21 feet 4 inches) and 2.5 meters (8 feet 3 inches) on the south side. Through these openings runs a large beam, 18.5 meters (60 feet 8 inches) long, fitted with 3-ton electric lifting gear, which serves the central room and hoists the torpedoes for submarine launching. The 2-ton overhead traveling crane deals with the aerial torpedo-launching service. A railed off gallery runs round three sides of the central room. The large bay on the north side is closed by a sail-cloth curtain. That on the south side is protected against the action of the waves by a strong wooden curtain stiffened by vertical steel bars. The necessary fittings, mooring bits, ladder-ways, etc., are fitted as shown.

The description of the various schemes which had been contemplated and of the one finally selected formed the subject of an interesting lecture delivered by Mr. Michel-Schmidt before the Paris Institute of Civil Engineers, at the special request of Mr. Cruppi, late Minister of Commerce, who assisted at the meeting as honorary president.

The dock for the construction of the lower portion of the structure, to be floated out and sunk, was put at Messrs. Schneider's disposal by the Forges et Chantiers de la Méditerranée. The dock, on opening the gates, provided a draft of water 3.5 meters (11 feet 6 inches) in the rear of the horizontal flooring, which rested on the stocks with the interposition of beams (see Fig. 5). The flooring was calculated for bearing a live load of 1,500 kilogrammes per square meter (308 pounds per square foot), a resistance which was reached when the bottom of the caisson had become sufficiently rigid to bear only upon the large beams, at which time the stocks carried a load of approximately 1,400 tons, a load lower than that of the caisson at the time of its floating. Under these conditions the load transferred from the stocks to the dock bottom amounted to about 2.5 kilogrammes per square centimeter (36 pounds per square inch). An important point which had to be considered in laying out this portion of the work was to adopt a combination making for the greatest possible degree of stability for floating out, compatible with a state of progress in the work such as to allow this to be easily completed at the final site. With ordinary iron caisson work a series of extension pieces can easily be bolted down to the main caisson when these are necessary. In the armored concrete work under review the necessary connections for this were not available. This consideration led to giving the armored concrete caisson forming the base of the structure a height of 15.5 meters (50 feet 10 inches) from the flooring in the dry dock, and to building on one side the main brackets for the overhanging room, the top of which brackets reached a height of 18.5 meters (60 feet 8 inches) above the flooring. The object of the arrangement, as stated, was to facilitate the work to be carried out at the site, but, on the other hand, special care had to be taken in the construction in order to make the draft of water and the height of the top hamper correspond with each other; the thicknesses had to be reduced to a strict minimum, as also the number of stays in the upper portion of the work, and the thickness of the concrete bed at the bottom of the caisson, etc.

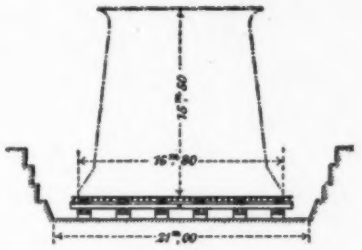


FIG. 5.

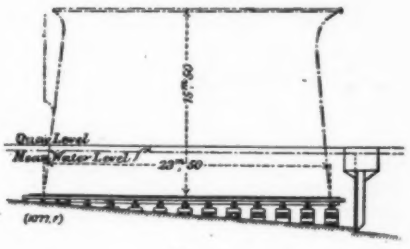


FIG. 6.

When the flooring in the dry dock had been suitably prepared, the bottom lacing for the structure was commenced. This lacing consists of a double armature with 16-centimeter (6¾ inches) meshes formed by 16-millimeter (⅝ inch) steel rods. The bars to serve as armature for the internal partitions are hooked to the bottom lacing, and are arranged in the shape of vertical binding straps. From the commencement of this lacing work a complete scaffolding system had to be built for supporting the bars; this covered the whole surface of the caisson. In order to prevent the adherence of the concrete to the bottom wood flooring in the dry dock, which would have prevented the floating out, the whole of the bottom surface of the structure was covered with a layer of strong packing paper, the paper being in its turn covered by a layer of tight-woven cloth, the object of which was to absorb the excess of dampness and to preserve the paper insulation. The bottom had to be made perfectly water-tight, a condition which has been secured by placing a layer of rich mortar, well worked down with the trowel, previous to commencing the concrete work. The concreting of the bottom was rendered more difficult by the presence of the internal cells, but it proceeded with great regularity, as also did that of the sides and the various internal walls.

In order to stiffen the caisson for the floating-out operation, two sets of horizontal armored concrete girders were built inside it, at the center and at the top, these girders being strengthened by temporary wood-lattice girders, bolted together (see Fig. 7).

As the caisson was to be deposited at a depth of 12 meters (about 40 feet) below sea level, its upper edge being only 3.5 meters (about 11 feet) above sea level, the shipping of water was to be feared during completion of the work, and to prevent this curved tops were provided round the upper edge. As above alluded to, the brackets for the overhanging observation room were built in the drydock as far as the considerations as to draft of water for floating out would allow, and a special system of armature bars was used in the rear portion of the overhanging room (see Figs. 9 to 12). The brass tubes and their accessory gear, together with the various mooring fittings, were built in the caisson previous to its floating out.

When the caisson was so far completed in drydock the sluice gates were opened, and it was gradually allowed to separate from the wooden platform. The wood stocks on the dock bottom had been previously weighted down by pig iron blocks. When the caisson floated it was ballasted in order to bring it level, and the mooring chains forming a bridle mooring on the east side wall were put in place. The caisson was floated out of the dock by the aid of two tug boats. When in the open the screw tug boat alone towed the caisson, the paddle wheel tug serving to steer it. In this manner the caisson was towed to buoy No. 23 of Toulon Arsenal, to which it was moored by one single chain, connected to the bridle mooring by means of

FIG. 7.

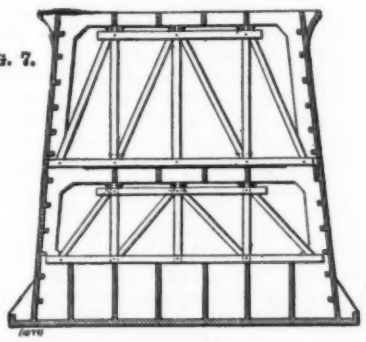


FIG. 8.

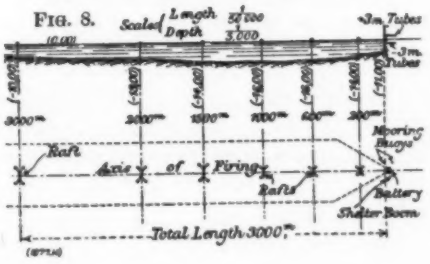


FIG. 9.

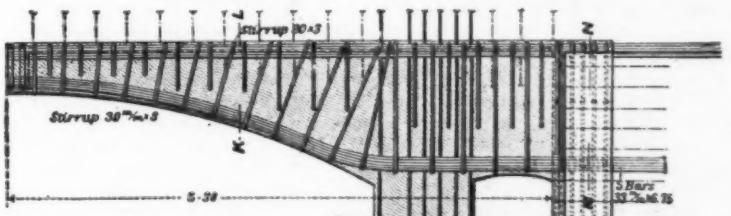


FIG. 10.

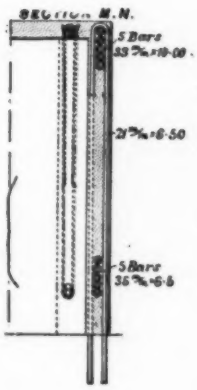


FIG. 11.

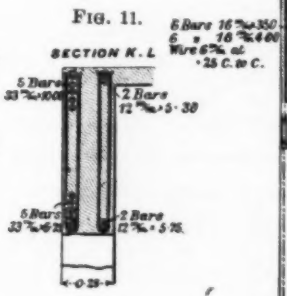
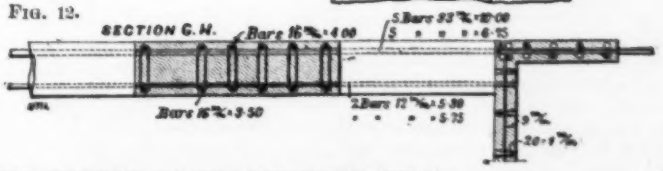

SECTION K.L
6 Bars 16 m/m x 3·50
6 " 16 m/m x 4·00
Wire 6 m/m at 25 C. to C.
5 Bars 33 m/m x 10·00
2 Bars 12 m/m x 5·30
5 Bars 33 m/m x 6·25
2 Bars 12 m/m x 5·75
0·25

FIG. 12.



THE SCHNEIDER TORPEDO-TESTING STATION IN THE MEDITERRANEAN.

a strong shackle. In this manner the caisson was free to swing round the buoy under the action of wind and currents.

The problem at this stake was to increase the draft of the caisson from 3.5 meters (about 11 feet) to 8 meters (about 26 feet) by building as much as possible of the superstructure while concreting up the lower portion of the caisson, so as not to impair the stability of the whole. The partitions were carried up to a height of 11.5 meters (38 feet), and the concreting of the bottom was given a thickness of 2 meters (6 feet 6 inches). The total weight corresponding to the 8-meter (26 feet) draft of water amounted to 2,600 tons. The work was divided into two parts, the internal and the external service, the latter comprising the depot for all the requisite material, wood, cement, iron and steel bars, sand, and stone. The barge for mixing the concrete was moored to the west wall of the structure opposite to the mooring buoy. It was, therefore, always on the lee side, the caisson being free to swing round the buoy, as above stated.

Two other barges and a tug served to insure the regular supply of material. The hoisting of the latter was insured by two windlasses mounted at a height of 15.5 meters (50 feet) from the bottom of the caisson on a provisional flooring built overhanging, and supported on a small girder. The men were carried to and from La Seyne. The material lifted by the two windlasses was distributed inside the caisson by means of wooden troughs, special care being taken to maintain the structure constantly on a level. Owing, however, to the action of the sea, it was impossible to work on the level and plumb-line method, and building had to proceed by taking reference marks. Electrical lighting was supplied by an 8 to 10-horse-power De Dion set.

The hawser for towing the structure from the mooring buoy to the final site prepared for it consisted of a rope 100 millimeters (4 inches) in diameter, surrounding the caisson twice, protected at the angles by mats, and suspended by hooks from the mooring rings fixed in the caisson outside walls. The whole of the top of the caisson was floored over carefully so as to afford a suitable platform for carrying out the sinking operations at the final site. The structure thus prepared, having a draft of 8 meters (26 feet), and forming a mass of about 2,600 tons, had to be towed over a distance of 19 nautical miles in a straight line (owing to leeway it covered 21 to 22 miles). The towing was effected by two tugs, having together 1,100 horse-power. The two ropes, 120 millimeters (4¾ inches) in diameter, were 80 meters and 100 meters (262 feet and 328 feet) long respectively. The speed was estimated to reach 2 or 2.5 knots, but owing to the yawing off the course and the violent churning produced by the reaction of the water on a plane surface, the area of which was 100 square meters (1,075 square feet), the speed was only 1.5 knots. Towing commenced at night time, so as to reach the final site by daylight. The departure from the Toulon roadstead, the navigating over the 10-meter (33 feet) channels and the junction into the main pass, were particularly difficult. The passage, which lasted in all over fifteen hours, was, however, accomplished in beautiful weather; but, notwithstanding, the safe arrival over the final site was viewed with much satisfaction by all concerned. Its success reflects great credit upon the engineers who designed and superintended the work throughout.

In order to locate exactly the site which the structure had to occupy on the sea bottom, buoys were placed at the four corners, formed of masts 15 meters (about 50 feet) high, imbedded in armored-concrete blocks weighing 2 tons, and sunk by the aid of the Priestman crane on to small platforms on the sea bottom measuring 4 meters by 3 meters (13 feet by 10 feet), their exact position being regulated by divers. Lines joining the tops of masts formed the basis for regulating the sinking operations. Four anchors, weighing 24 hundredweight, were thrown along lines bisecting the four angles; they were moored to 30-millimeter (1.18 inches) studded chains, connected by steel cables to buoys, thus making it possible to raise the chains rapidly. On reaching the site the tugs were stationed to the front and to the rear of the structure, and maintained the latter over the site while the four chains were being raised and fixed to it. Sets of tackle were fitted to the chains for tightening and for controlling the position of the structure. The coast being steep, two directing staffs, joined by a cord painted white, showed the alignment; the sinking operations were completed at night-time, and lights were suspended by the directing staffs.

Sinking was effected by pumping water into the various compartments; these were made to communicate with each other—port, starboard, and front, center, and rear. The port and starboard sides were each supplied by a Worthington pump delivering 150 tons (33,000 gallons) per hour, and the center cells by a 300-ton (66,000-gallon) Gwynne pump. The three pumps were supplied with steam from the boilers of one of the tugs, anchored opposite the east wall of the structure. By working the pumps together or separately, as was required by the conditions of stability, and by hauling in the slack or easing-off on the anchor chains to maintain the caisson in its correct position, sinking proceeded gradually until the structure was firmly laid on its seating. Settling was estimated to reach 12 or 13 centimeters (about 5 inches); it amounted to 15 centimeters (6 inches), with a difference of 4 centimeters (1.6 inches) from the front to the rear, corresponding to an incline of 1.6 millimeters per meter (1 in 625), a negligible quantity.

In order to allow the draining of the side cells, which had to be concreted, the central cells were first filled in with sand; a part of this sand ballast remains beneath the floor of the torpedo room. The work of concreting was divided into two gangs, one for the ordinary concreting operations, supplied from the east side with the aid of a revolving crane, mounted 3.5 meters (about 11 feet) above sea level; and one for the armored concrete work supplied from the north side by hand winches, mounted 6.5 meters (about 21 feet) above sea level. The lining and lacing for the superstructure were carried out under scaffolding, which served to support the vaults for the roofing. The work proceeded with regularity, and without incident, as also did the sinking of the riprap.

For establishing the stability of the battery as it now stands in its final position, Mr. Michel-Schmidt calls attention to the peripheral and internal framework being built of armored concrete, the rhythmical effect of the waves on the construction is much reduced. The vibrations are easily absorbed by the framework. Scouring at the base is not to be feared, owing to the method followed in the making of the foundation platform, this being in a trench, and lying directly on a rock substratum; while there is absolutely no risk of the structure overturning under wave pressure.

The current required in the testing station is produced by two 40-kilowatt sets, consisting each of a Panhard 65-horse-power gasoline engine, direct coupled to a dynamo. Current is produced at a pressure of 220 volts, and it serves to drive the air compressors, the auxiliary apparatus, lifting tackle, overhead traveling crane, and two pumps having a capacity of 3,300 liters (872 gallons) per minute.

A small engineering shop on land opposite the battery contains all the necessary tools and apparatus for regulating the torpedoes and for carrying out any repairs that may become necessary. The power required for this is supplied by a 100-brake-horse-power engine, supplied by two Babcock boilers, and driving a 70-kilowatt dynamo, the latter supplying current to a 40-kilowatt dynamo driving an air compressor similar to the above, having a capacity of 480 liters (17 cubic feet) of air at a pressure of 180 kilogrammes per square centimeter (1.17 tons per square inch); it supplies also the tools in the shop and other accessory apparatus.

The expanse over which the torpedoes are fired is illustrated. Although 3 meters (9 feet 10 inches) is generally the medium depth of immersion for which the torpedoes are regulated, it is desirable to have at the first portion of the course a depth of from 12 meters to 15 meters (39 feet to 50 feet). In order to follow the path of the torpedo, a series of rafts have been placed, as shown, along the firing line; the rafts have been exactly located by means of leading marks. A man stands on each raft and signals the passing of the torpedo with a flag, while the observator in the bow-window of the observation room takes down by chronograph the instant at which the torpedo is fired and at which it reaches each raft. When the torpedo stops at the distance for which its engine was regulated, a motor vedette boat picks it up, and takes it either back to the battery or to the engineering shop on land. The rafts are moored to two sets of buoys, one set on either side, by means of chains having in length three to five times the depth of water, according to their distance from the battery; the firing axis is determined by leading marks on land. Lights are mounted on the rafts. The battery is sheltered by a boom formed of two wood beams, 20 meters (65 feet) in length, held between three buoys, which form a right angle, and are held to the bottom by concrete blocks weighing about six tons.

The service is carried on by two motor vedette boats; a motor boat for the engineers and government officials; a long boat, towed by one of the vedette boats, fitted for carrying three torpedoes and for supplying the battery with fresh water; and a dinghy for the man in charge of the battery.

In this installation Messrs. Schneider had the cooperation of Mr. J. M. Vigner, a French engineer, in conjunction with whom they have carried out a large amount of civil engineering work. M. Creisson, contractor, Marseilles, had charge of the dredging operations, and laid the stone packing. The Société Générale de Constructions en Béton Armé (Anciens Etablissements Dumesnil) executed the armored concrete work, for which they undertook the responsibility, together with Messrs. Hennebique.

HEATING STEAM BOILERS WITH PRODUCER GAS.

ANY results so far obtained in practical operation as to the use of producer gas for the heating of boilers shows this plan to be quite satisfactory. The subject is treated by C. W. Bildt in a recent issue of "Jernkontorets Annaler," the following conditions being shown to be necessary for a satisfactory application of the method: 1. Between the producer and the steam boiler should be arranged a combustion chamber of sufficient dimensions to enable the flame to attain the available intensity before striking the cold boiler walls, so as to avoid the formation of soot. 2. As there should be a uniform gas current, the producer has to be fitted with an automatic charging and distributing device. Several such plants have been installed in Sweden, viz. in the Norrköping "Vulkun," in an Eskilstuna factory for the operation of a Babcock & Wilcox boiler of 265 square meters heating surface, in the Bergvik-Ala sulphite works, in the Langshytta Iron Works, in a Dedgerhamm cement factory, and in the Rydö paper factory. Anthracite, peat, wood, and wood shavings can be used as fuel. The boiler walls should be provided with a sheet or rather with a double sheet to prevent an admission of air, the combustion air circulating through the interval, being preheated by the radiated heat, thus rendering the heating of the boiler more effective. The gas ducts should also be perfectly tight and well insulated. Comparative experiments performed in the sulphite factory just referred to have given the following results:

	In Producer.					
	CO_2	O	CO	H	CH_4	N
Anthracite gas	3.3	0.9	27.5	10.4	6.2	51.7
Wood gas with blower wind	9.5	1.5	19.4	6.6	5.0	58.0
Wood gas with steam jet	7.4	1.2	27.7	10.3	5.0	48.4

	In Combustion Chamber.					
	CO_2	O	CO	H	CH_4	N
Anthracite gas	14.0	5.2	0.8	...	..	80.0
Wood gas with blower wind	15.4	2.4	2.4	....	....	79.8
Wood gas with steam jet	12.7	4.0	0.0	....	....	83.3

From the above analysis it is seen that the quality of the gas is more satisfactory if the producer is operated by a steam jet blower than in the case of operation by blower wind. The height of the fuel layer in the generator is dependent on the quality of the fuel and the working of the generator, being 1 to 1.5 meters in the case of anthracite and 3 to 4 meters in the case of peat and wood shavings, according to the percentage of water. Fuel containing a smaller percentage of water requires a thicker fuel layer than fuel containing much water. The following advantages are claimed for gas heating of steam boilers as compared with other methods: Greater efficiency, smaller fuel consumption, a more uniform and perfect combustion and lesser formation of smoke and soot. The operation is cheap and convenient. The fuel used in connection with these experiments had the following composition and heating value:

	Moisture %	Coke. %	Volatile Components. %	Ashes. %	Heating Value. H. U.
Anthracite	2.0	57.0	33.5	7.5	7,640
Peat	19.8	20.7	52.7	6.8	5,600
Sawdust	46 4	0.5	....	....	5,330

A great many of the steel balls made for bearings are discarded because of imperfections. Some are not round, some unevenly hardened, and some have flat spots or other surface defects. The best of these are assorted into one or more inferior grades for use in the cheaper bicycles, clothes wringers, carpet sweepers, and the like. Many, however, are unfit for service as bearing balls, and such have become quite popular for polishing small metal objects. A typical mode of using them for this purpose is to employ a small tumbling barrel made for the purpose. The objects to be polished are placed in this barrel, together with a supply of balls, and a quantity of a soap solution. According to the Brass World, this solution is made of a special material. Some ammonia may be added, depending on the class of work. The barrel is then operated and, after a time, the objects become highly polished, the effect being almost equal to burnishing.

THE MARATTA SYSTEM OF COLOR.

PAINTING ON A SCIENTIFIC BASIS.

THE color system invented by H. G. Maratta is based on a careful study of the mass of facts that form a basis of the art of painting, decorating, and producing color harmonies. While the pigments are compounded and arranged in harmonious relation to natural, pure, or spectrum colors, the Maratta system is based upon reflected light, not light itself. Heretofore, as far back as modern knowledge extends, it has been the practice of the student of color to deal with light. This the artist or decorator cannot do. He must use pigments, which depend upon reflected light for their effect.

The manufacturer of prepared pigments, inks, dyes, etc., compounds and markets his produce without calculating the relationship to natural color or each other. The artists select such pigments as years of experience and accumulated knowledge may dictate. They proceed to paint and produce color harmonies, without knowing that the colors of nature are limited to those of the spectrum band, in the same order that all the sounds used in music are limited to those that occur between the tonic and its octave. The spectrum band is an imperceptible blending of colors from a dark, to red, orange, yellow, green, blue, and purple, then passing again into darkness. It is impossible to tell where the red leaves off and the orange begins, or where the orange leaves off and the yellow commences, or the beginning or ending of the green, blue, or purple.

In the Maratta system, intervals are selected in the spectrum band, and imitated with pigments, which are pure, permanent, and will mix chemically without reaction (these intervals may be the harmonic number six or twelve).

The great variety of so-called broken tones, grays, etc., are simply the same colors that appear in the spectrum band, lowered by darkness. The gray pigments that represent the spectrum band in these new colors are lowered by mixing mathematical proportions. The philosophy is, that if all the color pigments were mixed together, regardless of the proportions or quantities, a dubious tone is produced for want of a better name, it has been called "gray," "brown," "mud," etc. This dubious tone really retains the character of one of the spectrum colors lowered vertically (provided the proportions are such as not to produce the neutral or black-and-white gray). If more red is used in the mixture, the result is a red gray or hue; more yellow produces a yellow gray or hue; more blue, a blue gray or hue, etc. These grays move along a horizontal line of the spectrum band, the color of the resultant gray or hue depending upon the proportions, power, or quantity of the various colored pigments used.

It will be understood from the above that no matter how many pigments are mixed, they must result in a hue that retains the character or tone of one of the colors of the spectrum band.

It will be seen that the artist is limited to the intervals selected for his brightest pigments, and the same intervals or pigments lowered to the darkest or a point where they still retain their character as colors.

The great variety of grays found in all harmonious color combinations come about through juxtaposition with other grays and colors by simultaneous contrast, or when this common scale is changed to one of the analogous scales by using a proportion of any one of the colors, with all the others, and the same proportion of the hue of a color in all the hues.

Thus a little green color added to all the colors, and the same amount of green hue added to all the hues, change the common scale to one of a green dominant, which is much more beautiful and harmonious than the common scale.

Any of the colors may be used in a like manner, or the hues may be lowered by the addition of black. The Maratta pigments consist of six colors and six hues or grays. The six colors represent the six intervals of the prismatic spectrum, namely, the red, orange, yellow, green, blue, and purple. The six hues are the red hue, orange hue, yellow hue, green hue, blue hue, and purple hue. These hues are standard tones, and have the same source as the secondary colors. They are the same colors reduced or suppressed in their intensity, removed or carried into the distance from the colors for the convenience of the artist in obtaining shade shadow, aerial perspective, and subtle harmonies. Theoretically the red, yellow, and blue produce orange, green, and purple. Likewise the orange, green, and purple produce the red, yellow, and blue of the hues or grays. We call red pigment red, because it contains more red molecules than yellow, or in other words, the red has an excess of red over the yellow and blue. Blue is called blue for the reason of its having more blue than yellow and red. Yellow is called yellow for the reason of its having an excess of yellow over the red and blue.

It should be known that all pigments are composed of red, yellow, and blue, and in manufacturing pigments a red is selected which contains the smallest possible amount of yellow and blue. If the red contains more yellow than blue it will incline toward the orange; if more blue than yellow it passes to the purple side. The yellow must be such that it contains the smallest amount of red and blue, otherwise it will incline toward the orange or green, and the blue should contain the smallest amount of yellow and red, to keep it between the green and purple. For the above reason it will be understood why red and yellow will not make as bright and pure an orange as one built up synthetically. If the yellow and blue are mixed to produce a green, as both yellow and blue contain some red, the green is neutralized or lowered. In mixing blue and red for a purple, yellow is added and the purple is lowered in luminosity. Inasmuch as the six colors represent the extreme foreground colors in a normal light, the six hues represent the extreme background colors. It follows that a mixture of the two in varying proportions will represent the intervening color in its true aerial perspective value. Thus if a green color is used to represent green objects in the immediate foreground, the green hue will represent the same kind of green object in the extreme background, and a mixture of the color and hue in varying proportion will represent the same greens in the intervening space.

A yellow green is produced by the addition of the yellow color or hue, a blue green by the addition of the blue color or hue, etc.

A great advantage in using the Maratta pigments is that any of the colors may be grayed or lowered without changing its character as a color. In the older methods of mixing color, for example, yellow color is grayed or lowered by the addition of red and blue. But only when the proportions are just right will a yellow color be reduced to a yellow-gray, as too much red will change the yellow to an orange-gray on the warm side, too much blue changing it to a green-gray on the cool side. Other proportions change it to a neutral. Another method of lowering a color is by adding its complement. Should we desire to lower the yellow to a yellow hue or yellow-gray, we would find it difficult to do so without changing its yellow character as a color. This has been entirely overcome by the use of the Maratta pigments, as each of the six fundamental colors of the spectrum has a hue or gray, by the addition of which the colors may be lowered without waste of time or material, and without changing its character as a color. These hues are so nicely mixed that they change by simultaneous contrast with any of the colors placed alongside of them.

To illustrate color harmonies without the use of pigments is most difficult. The Maratta chromatoscope chart illustrates how the harmonies, contrasts, melodies, chords, etc., are produced in a very simple manner. This chart is published at present for the use of printers. It is a scientific arrangement of the six colors and six hues that will enable a novice to select harmonious color combinations; it being so arranged that every seventh color is a complement, also showing the warm and cool colors, hues and tints on either side of the complement. One has only to select a color, hue or tint he wishes to run on the press, the complements, contrasts, harmonies, chords, melodies, etc., are found at once. The harmonies are reached by going from the colors to the hues, or hues to hues. The printer selecting a two or more color combination for colored stock, has only to pass the stock over the chart until the color the stock most resembles is found. From this he learns the color hue or tint of the stock which is the keynote, and is treated as one of the colors of the combination, it being a matter of choice whether a harmony, melody, or contrast is selected.

Water and oil pigments for the artist and designer and printing inks for the printer are all matched and numbered the same as the numbers on the chart. The advantage of this arrangement is this: Should the artist use the paints on the sketch, he marks the number of the same on his sketches; the proofer and printer can match this same color with the same number in the printing inks, thus saving much time in mixing and matching.

ACCIDENTS IN AERIAL NAVIGATION AND HOW TO MEET THEM.

By DR. FLEMING.

THE frequency of accidents is naturally increasing as aerial navigation becomes more and more common; it is necessary therefore to study their causes, in order to avoid them.

Asphyxiation by gas is frequent, especially in filling the balloon. Illuminating gas as well as hydrogen gas has caused asphyxiation, especially hydrogen when produced chemically and not electrolytically. The symptoms are nausea, headache, dizziness, and shortness of breath; the outcome is usually death within a week. It is recommended to use hydrogen only if electrolytically produced, or at least to avoid sulphuric acid, which contains arsenic. Illuminating gas has caused asphyxiation of men employed in filling balloons, when holding the hose to the inlet of the balloon. This is often due to their position, for they lie underneath the cover. Not being supplied with fresh air they perish. The danger could be avoided by fixing the hose to the opening by means of a pipe. These accidents are fatal only in exceptional cases.

Explosions of gas or bursting of balloons is not frequent. In the first case a certain proportion of gas and air must be mixed to cause an explosion. The latter case will happen only when the filling valve is erroneously closed, as in the case of the American balloon "Conqueror," which burst in Germany in 1900. The balloon forming a parachute in such cases usually prevents injury to the passengers. If, however, the explosion ignites the gas, then, as happened to Zeppelin, destruction of the balloon follows. This danger is greatest in dirigibles, the gas becoming ignited by the sparks of the motor. Lightning has caused explosions only in captive balloons, the steel cable being the reason.

It should be made a rule, especially for dirigibles, to carry parachutes, as in collapsing they will not assume the parachute form as did the old spherical balloon, in case of accidents in midair.

There is a greater frequency of accidents in landing. Ignition by opening the valve, before the gas has fully escaped, is one cause of them. Another danger is the difficulty in finding a proper landing place. Gales have often thrown navigators from the basket when about to anchor. The legs and feet are more exposed to injury in landing than the upper parts of the body. In any event, the greatest caution is required in landing.

Landings in water are frequently dangerous because of fog or clouds, which obstruct the view, sometimes by mistakes in reading maps. It is very difficult to make proper observations by means of the sun, the moon and the stars, when above the clouds. Of course the nearer to the seashore the more care must be taken in alighting, in order to avoid the water. The rope, made of a material which will float on water and not sink, should be used whenever there is any doubt about the location. This may avoid landings in water.

In order to keep the balloon afloat when landing in water, it is necessary to provide a device to close the inlet from the basket and to prevent the total loss of the gas for at least some time. Though life preservers should be provided, they will only be of limited usefulness. A good balloonist should not abandon his balloon and try to swim before all hope of rescue is gone. Moreover, the chances that a balloon has been seen are much better than the chances of a man being seen swimming in the ocean. This was proved during the last Gordon Bennett race, where several landings and rescues occurred in the North Sea.

Nausea, faintness, and other unpleasant sensations in higher altitudes can best be guarded against by taking oxygen. Little danger exists of serious illness through atmospheric conditions when the balloon rises very high. Cold and intense radiation of the sunlight are the most frequent causes of eye and skin troubles. The best means to combat them are similar to the ones used in ascending glaciers. Yellow veils or green glasses will prove very useful.

So far, statistics show one accident to 5,000 miles of aerial travel.—Umschau.

Reports from builders of steam-shovel and dredging machinery show that electricity as a motive power in working these shovels and dredges has gone beyond the experimental stage, and that in the future design of such shovels and dredges electricity is going to play a very important part. In the Western States, especially where water power is available, many shovels and dredges are being put into use and equipped with motors to be operated electrically.

THE MAKING OF AUTOMOBILE TIRES.*

FROM RAW MATERIAL TO FINISHED PRODUCT.

BY SNOWDEN B. REDFIELD.

For many years the "rubber man" has been considered very close as regards information about the making of his various products.

A more or less ragged story bearing on this subject has it that one rubber manufacturer desiring to discover some of the secrets of one of his competitors disguised himself as a minister and applying at the office of the rival rubber works he stated that he was looking for some general information in regard to manufacturing which would help him in a certain sermon which he was endeavoring to prepare. After a critical examination of his face and his costume he was very politely shown through the mill.

At one point the minister asked if he might take home with him a small sample of the rubber and upon having received permission, he took out his penknife to cut a small piece from one of the piles near by. Before making a cut, however, he passed his knife blade between his lips, and as a rubber man knows that a wet knife will cut rubber where a dry one will not and very few other people know this fact, it took but an instant to seize upon the bogus minister and cast him out the back door.

Pursuant of this policy, it is not strange that there are many old-fashioned ways of making rubber goods, largely employing hand labor, still in existence. The accompanying photographs are illustrative of an up-to-date policy involving the use of modern machinery to do the work which is still very largely done by hand in many places.

The machine, which is of particular interest as a direct replacer of uncertain hand methods of making automobile tires, substituting therefor exact machine methods, is illustrated in Fig. 1 and also in Fig. 5, while Fig. 4 illustrates the manual method still very largely in use. As very little is known to the general public in regard to the manipulation of rubber, and as automobile tires are a product which is of very real interest at the present time, a description of the process of manufacture will not be out of place.

MECHANICAL MASTICATION.

The rubber gum in the crude state comes from the South American rubber plantations in irregular lumps, its general appearance and the size of the lumps depending upon the kind of gum. In Fig. 2 the steel tank, as will be seen, contains these irregular lumps of crude gum, which are soaking in hot water, the purpose of this being to soften and clean the lumps of gum. After this soaking for a considerable length of time, these lumps are passed through the grinding or masticating machines which are seen in the background of Fig. 2.

These machines consist essentially of a pair of toothed rolls of very heavy construction and requiring considerable power to do their work. One of the rolls travels about three times as fast as its neighbor and, as intimated, both rolls are provided on their surfaces with heavy pyramidal projections, or teeth. The projections are in parallel rings around the rolls and those on one row coincide with the grooves on the other roll so that the two rolls, although each is provided with projections, and as said, one traveling three times as fast as the other, are made to travel quite close together.

The surfaces of the rolls are flooded with cold water and the irregular lumps of gum which have come from the softening tank are thrown in between these rough rollers, which, it should be said, are of course both revolving inward, tending to draw the gum down in between them. The gum is very stiff, but the projections on the rolls draw it down between them, crowding the lumps into the very small space between the projections, and the different speeds of the two rolls cause the gum to be thoroughly crushed and torn apart; in fact the word "mastication," or chewing, describes this action best. It is in reality a very powerful tearing asunder of the fibers of the gum which is passed round and round through the rolls a great number of times until thoroughly masticated.

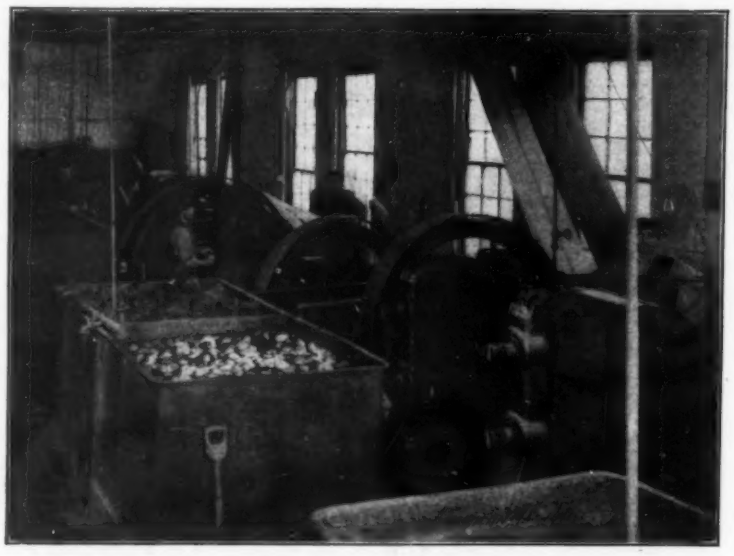


FIG. 2.—GRINDING OR MASTICATING ROLLS.

SHEETING AND DRYING.

After this thorough chewing the material is passed through other sets of rolls different from the first set only in the fact that they are provided with shallow corrugations along their surfaces instead of projections, and by passing the now masticated gum between this second set of rolls the material is formed into strips or sheets and the process is termed sheeting. These rolls also revolve at different speeds. As the material passes down between the corrugated rolls it comes out in a band underneath. The operator catches the loose end and feeds it again into the top of the machine, which produces an endless band of the gum, which is full of pits and indentations resembling very closely a rubber sponge or a sheet of rubber sponge material. The oftener the material is passed between these rolls the better it is worked and the more continuous becomes the band of material.

After a large number of passes through these sheeting rolls, the band is cut apart and taken to the drying room where it is hung in the dark for a sufficient

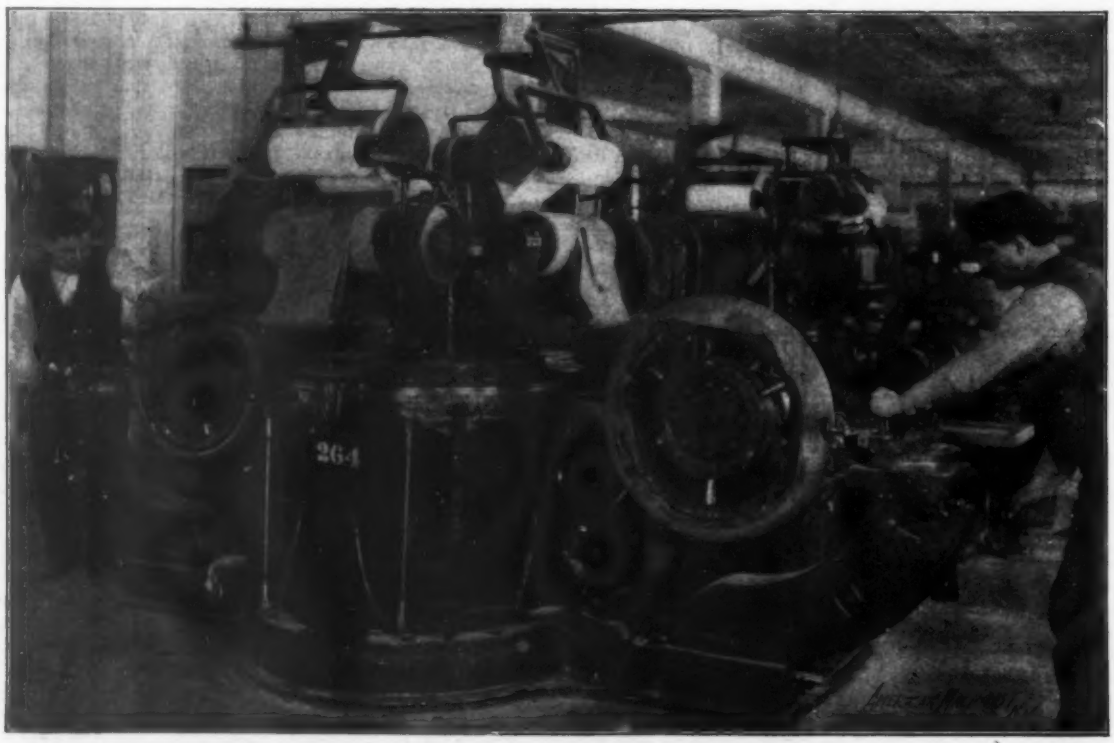


FIG. 1.—A MACHINE-MADE AUTOMOBILE TIRE. ROLLING THE LAYERS INTO PLACE.

THE MAKING OF AUTOMOBILE TIRES.

* The American Machinist.

length of time to make it perfectly dry. In practice it is found that the process of washing or soaking and the subsequent masticating and sheeting have caused a loss in weight of material of from 10 to 40 per cent, depending upon the kind of gum. This loss is due to the removal of impurities, such as dirt, clay, pieces of wood, etc. The drying is done in darkened rooms because light has a chemical action upon the gum at this stage.

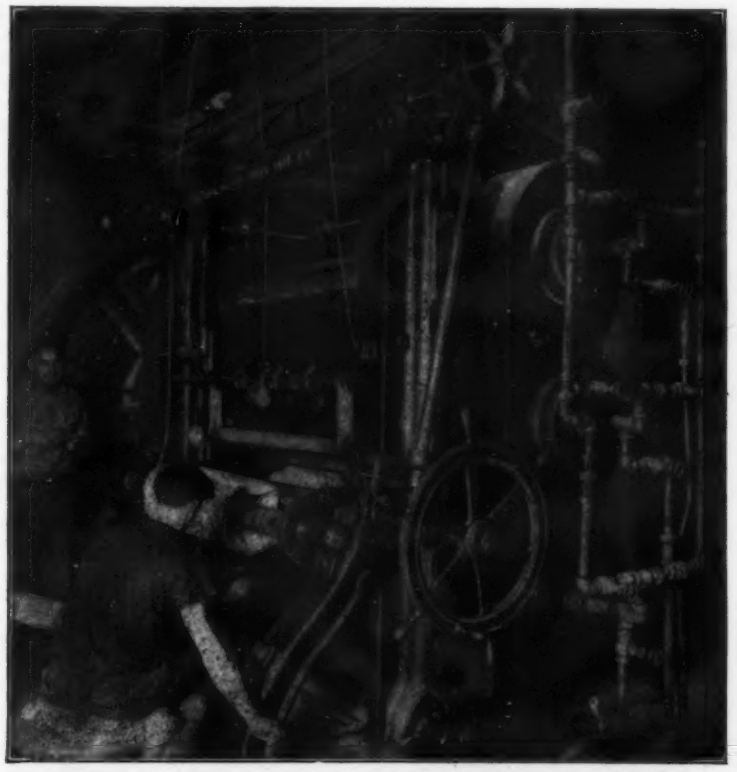


FIG. 3.—THE CALENDER ROLLS. REELING OFF THE RUBBER STRIPS.

MIXING.

After being thoroughly dried, the sheeted gum is passed through a set of rolls which are heated by steam and the surfaces of which are smooth, without either projections or corrugations. These rolls, however, travel at different speeds as before, and by passing the sheets of gum between them the material is thoroughly worked and kneaded, and acts, in fact, very much like an exceedingly sticky form of dough. The gum sheets are bunched together and passed through the two rolls in lumps, the action of the rolls being to squeeze and draw out these lumps into a wide sheet. The material is very sticky and the steam-heated rolls make it even more so, so that as it passes through and is kneaded and worked by the action of the two rolls traveling at different speeds, it crackles and snaps and draws in quite a remarkable manner.

The operator, as with the sheeting machine, reaches down and draws up the end of the band of gum which is passed through the rolls and feeds it in again through the top, making, as before, an endless band. By the action of the heat and the smooth surface of the rolls, this band of gum is very much smoother than the product of the first sheeting machine. In fact it does not resemble a sponge in any way at this stage.

As the gum band, which will be three or four feet wide, becomes fairly continuous, the operator makes a knife cut across the band as the rolls slowly revolve, this cut reaching not quite to the farther edge of the band. He then folds back the loose edge in a diagonal fold and allows this double thickness of material to be forced, squeezed and torn through between the revolving rolls. This further assists in the thorough working and kneading of the fibers so as to make the gum uniform, plastic and elastic.

It is on rolls of this character also that the mixing is done; that is, the chemicals which go to make the final vulcanized product, the principal chemical of which is sulphur, are mixed with the gum. This mixing is continued until it is assured that the chemicals are thoroughly and evenly distributed throughout the mass. These vulcanizing chemicals, that is, their proportions, are what constitute one of the secrets in the successful manufacture of rubber, and the particular chemicals used and their proportions depend upon the kind of rubber which it is desired to turn out. It is generally understood that this method of vulcanizing, that is, by mixing in dry chemicals, mostly sulphur, and the application of heat and pressure, was invented by the original Goodyear, who made most of the extensive experiments when the rubber business was very young and largely discredited.

CALENDERING.

Following the thorough mixing, the rubber gum is passed through the calender rolls, which are shown in Fig. 3. These rolls revolve at slow speed and again are steam-heated. It will be seen by the halftone that there are three rolls, one above the other, and in order to understand the action of the machine, it should be understood that the upper roll revolves in a clockwise direction as viewed on the end in the halftone. The middle roll viewed in the same way revolves in a counter-clockwise direction, while, of course, the bottom roll again revolves clockwise. All three of these rolls revolve at the same speed. The object of these rolls is to draw out the rubber gum containing the vulcanizing materials into thin sheets. In order to do this, the mass coming from the mixing rolls is thrown into the space between the top and middle calender rolls and in its present condition the mass is exceedingly sticky.

As the rolls revolve the mass of sticky gum is drawn between them in a thin sheet, while the bulk of the material remains behind sticking to the two revolving rolls, boiling over itself and crackling and snapping in a manner which it is impossible to describe and which is probably done by no other material besides rubber gum. It seems strange that the whole mass is not drawn through at once, nevertheless it is a fact that the rubber which comes out on the other side of the rolls, which is the near side shown in Fig. 3, is a very thin, smooth, and even strip of material which is, of course, very sticky and which consequently sticks to the surface of the middle calender roll. As it travels around this roll, it is cut into strips of the desired width by means of knives which are shown in the illustration attached to a cross bar in front of the middle roll.

Passing around this roll it goes in again between the middle and bottom rolls, around the latter and finally out in front of the operator who is shown sitting down. By the adjustment of the calender rolls rubber gum of any desired thickness may be made, and although the material is so sticky and so difficult to handle, it is possible to gage the thickness of these sheets to very accurate dimensions and to make them very thin indeed.

In order to handle this delicate and exceedingly sticky gum in the shape of strips, it is reeled off from the calender rolls between sheets of cotton cloth. A reel of this cotton cloth is shown almost in the center of Fig. 3, and at the bottom, to the left, is seen another strip of it coming from a second reel outside of the picture. By reeling off the thin gum strips between layers of cloth, the strips are easily handled and transported and prevented from being torn or from accumulating dirt on their very sticky surfaces. When desired

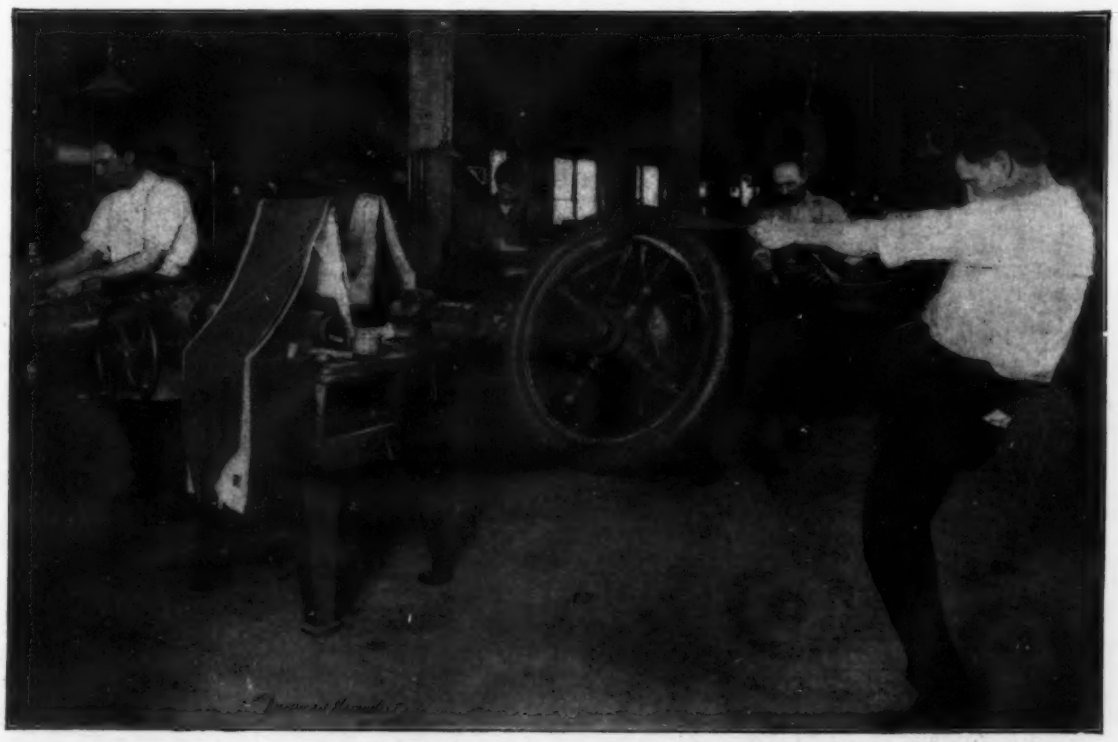


FIG. 4.—"HAND-MADE" TIRE. STRETCHING THE FABRIC.

THE MAKING OF AUTOMOBILE TIRES.

it is an easy matter to unreel these rolls of cloth and to separate the gum from the cotton.

FABRICATED RUBBER.

Besides making these strips of rubber, these rolls are used for forming fabricated rubber, that is a kind of canvas permeated with the rubber gum and having one side composed of the fabric and one side of rubber. The nature of this material is easily recognized upon examining the inside and outside surfaces of an automobile or bicycle tire where the fabric surface is plainly seen on the inside while the rubber is on the outside.

To produce this fabric, long strips of the canvas, which have been previously coated on the opposite side with a certain kind of rubber cement, are fed through between the middle and bottom calender rolls in such a way that the rubber gum adhering to the second or middle roll is squeezed down upon this canvas and caused to thoroughly permeate it and become firmly adhered thereto. Underneath the bottom roll the fabricated rubber, that is the canvas permeated with the rubber coating, is reeled off between strips of the cotton material already spoken of, and it is this operation which is being performed in Fig. 3, where the dark strip of rubber fabric, shown as coming from underneath the bottom roll, is being wound up by the operator in a roll of the white material which is seen coming from the left side of the picture.

It is this fabricated rubber which is used to make up the outer cases of the automobile tires. The fabric is taken to large tables where it is cut on the bias into strips about 18 inches wide and 5 feet long. These bias strips are next overlapped end to end in series so as to make a long strip, and in order to facilitate handling they are carried about on the strips of cotton goods before spoken of. In Fig. 4 at the left center will be seen several sheets of this bias material hanging over racks ready to be made into tire casings.

HAND-MADE TIRES.

To make the outer casings of the tires by the old hand method the illustration in Fig. 4 will give a very clear idea. A cast-iron core is fastened onto an arbor which is free to revolve like a wheel on an axis and this axis may in turn be rotated in a plane perpendicular to the plane of the core or wheel. The arbor may be prevented from rotating in one direction by means of a ratchet on its axis and the axis itself may be clamped so that it cannot be turned in its own plane of rotation.

It must be understood that the fabricated rubber is very sticky and it is this characteristic which enables the operator to fasten the strips together on the bias edges simply by laying them together and applying a little pressure, so as to form a long strip of several short strips.

The first operation of building up a tire casing, or shoe, as autoists would call it, is to coat the surface of the core with a special kind of cement to make it sticky. Next the operator throws over his shoulder a strip of the fabricated rubber, while he lays one end of the strip tightly down on the core. Due to the general stickiness of the material itself and also to the cement with which he has coated the core, the fabric adheres very strongly to the cast iron, and then by main strength, as vividly shown in Fig. 4, the operator draws the fabric around the core, using his utmost endeavor to put a uniform stretch throughout the material as it is drawn around.

It may occur to the reader to ask why the material does not wrinkle and crumple up as it appears that the flat strip of goods is laid around the circular section and bent in two directions. The answer to this is that the material, being cut on the bias, with a little persuasion will lie smoothly down all over the surface of the core. It will be understood, of course, that as the operator draws the material around the core, the latter is rotated a little at a time by hand so as to wind up the material, the ratchet on the axis acting to keep the core from turning toward him when he is drawing the material or putting in the stretch. Two, three, or four layers and possibly more of the material are laid one above the other and the ends are overlapped, forming a complete circle of the tire, care, of course, being taken that the overlaps do not come opposite one another in the different layers so as to make a rough place in the tire.

During the process of building up, the beading is put in around the rim which nearly always exists in an automobile tire to assist in fastening the outer casing to the rim of the wheel. This beading is simply laid in between the folds and the material itself is tucked and folded around the beading. By considerable coaxing it is caused to lie smoothly without any wrinkles, and its general sticky nature helps in holding the different layers and the folds together in a very neat manner. It should be said that the beading itself is a ring of rubber material very often containing a braided wire center in order to give it stiffness.

At the left of Fig. 4 and also at the right center of the picture just beyond the hands of the operator who is drawing the rubber material, can be seen two other operators who are folding down the strips of fabric around the beading at the rim, and it is seen that each is using an instrument consisting of a small disk wheel mounted in a handle which he rolls around the fabric causing it to lie smoothly down over the beading. In order to assist in making the tire strong, special strips of fabric are laid around near the rim, which act as reinforcements, thus holding the parts together.

MACHINE-MADE TIRES.

So much for hand-made tires. The objection to the hand-made tire is the fact that the amount of stretch given by the operator is anything but uniform as he gradually pulls the material around the core a short stretch at a time. Also as the day goes on, he naturally becomes wearied, and the tires which he makes at the end of the day do not have as much stretch as those which he makes at the beginning of the day, and in all probability will not be as good.

In order to obviate these sources of irregularity, the Goodyear Company has gotten up the machine illustrated in Figs. 1 and 5. As will be seen, in the center of this machine is a revolving turret which contains four rolls of fabricated rubber material which is to be made into the outer casings of the tires. In the top rolls is seen the cotton cloth which comes from the calender with the fabricated rubber, and which is reeled off and separated from the fabric onto a small roll which contains only the cotton itself. The rubber fabric passes down and around several rolls whose office it is to give the proper tension to the material.

The central turret with its rolls is mounted on a ball-bearing spindle and may be rotated so as to bring the different rolls opposite the two different operators who handle one machine. Suitable locking devices are provided to hold the turret in any one position. The object of having so many rolls of material is that the layers going to make up the tire are cut on the opposite bias in adjacent layers so as to give uniform strength in all directions to the tire. Thus after each of the two operators has put on a layer of one bias from the roll of material in front of each, the revolving head is turned 90 degrees and the operators then reel off the material for the next layer cut on the opposite bias. In this way neither of the two operators has to wait for the other one because each is provided with a roll for himself on each bias.

In this machine it will be seen that the same core is used as with hand work, but this core is mounted on an axis which may be turned by power and which is provided with two speeds of rotation. The first operation is as before to apply the cement to the surface of the core and then to draw out the fabric as shown on the left side of the machine in Fig. 5. The end of the strip is carefully pressed down upon the cemented core so as to make it adhere firmly and then the slow speed rotation is applied to the core itself. This rotation draws out the fabric, the correct and uniform tension being given to the fabric by the rolls mounted on the central turret of the machine, which tension is adjustable by means of weighted brake bands. After each layer has been thus accurately laid on, the material is cut off on the bias, the ends of the strips on the core being lapped over and pressed down so as to make a continuous band. After this the operation shown in Fig. 1 follows.

FIG. 5.—A MACHINE-MADE TIRE. STRETCHING THE FABRIC.

Here a lathe-like attachment on the machine is brought into operation. The core is now revolved at high speed by the power mechanism and, by means of the hand wheel shown on what may be termed a tool rest, various rollers and formers are brought into action which press the fabric tightly together in its various layers and which fold it down over the sides of the core, making it lie flat in a smooth and continuous surface.

At the left of Fig. 1 the operation of rolling in the beading around the rim is seen. By the adjustment of the tool holder to an index mark, the correct diameter for the beading is insured and its rolling in is a matter of but a moment, and is, of course, accurate. By means of this machine an operator may make four or five tire casings while one is being made by hand by the old method, and at the same time it is clearly seen that the machine-made product is uniform in tension in all its layers and in all parts of its circumference. The machine also smoothly and evenly rolls down the layers upon themselves and the core, making a far superior job as compared with the hand-made tire.

(To be continued.)

THE MAKING OF AUTOMOBILE TIRES.

THE LEONID SHOWER.

A METEORIC DISPLAY NOW DUE.

THE stars are due to fall on the nights of November 12th to 14th, a fixture in the celestial schedule of events. There is a secular change in the period of this particular display, a slow movement along the calendar, but it is only in the progress of many years that the alteration of the period amounts to so much as may be measured by a single night. Last year's display fixes the date for this year and for many years to come.

The November meteors will scarcely be at their best this year. In fact the earth cuts their orbit at perhaps its most sparsely studded spot. This shower has a period roughly corresponding to the generations of human life, roughly computed as three to the century. The last great display was due in 1899, but it was a disappointment when compared with former manifestations of this periodic maximum.

This year the earth crosses the orbit of this belt of minuscule members of the solar system at a point ten years away from the maximum density, about a third of the circuit of that orbit. The prospects, therefore, are that the display will not approach anything like the brilliance that from time to time has been observed. On the other hand, the exhibition, chiefly in the early morning hours of November 14th, should far exceed the count of the wandering stars which blaze for a moment almost every night, silent flights of cold incandescence.

The penultimate display was a great show in the skies. It was spread over three years, the peak of its magnificence in 1866, a heavy fall in 1867, and what might be called a smart shower in 1868.

But the 1833 rain of the heavens was most astounding. The eastern seaboard was most advantageously situated for observation on the night of November 12th and 13th. The stars fell as fast and thick as flakes of snow on a winter day. Prof. Olmsted reckoned that 240,000 gleaming trains were visible in the course of nine hours. To the ignorant it presaged the crack of doom, the beginning of the rolling up of the heavens like a scroll.

There yet live those who saw the rain of fire and who describe how in every countryside the unlearned people sought the fields and passed the night in agony of fear, with prayer and supplication. To the faithful it was a night of terror, to those whom hope had abandoned a night of a frenzy of wild excess.

Such scenes were repeated, with variations according to the nature of the population, all the way from Nova Scotia to the Gulf of Mexico. It spoke well for the moral fiber of the several communities that their terror sought a religious awakening, for it was in the era of the great unrest, the period of the great unsettling out of which arose so many new religions, that fever of new faiths.

If such it was among the ignorant, far otherwise among the learned. From the star rain of 1833 dates the beginning of all intelligence of these recurring phenomena. The astronomers, not mad nor undevout, but keen in their zeal to carry on the observations to whatever end might come—for then they had no knowledge one whit above the multitude praying in the fields with dervish howlings—then first found the key to the riddle of these visitations from the universe beyond our world's husk of air.

To their trained eyes these roving streaks of light were not haphazard tracery upon the dome of night. Each ball of fire followed a course all its own. Their tracks seemed aimed at every spot in the bounding horizon. Some even were seen to mount upward to the zenith and beyond upon the distant vaulted slope. Patiently the observers laid down upon the celestial chart each track as they were able to pick it from the tangle of crisscross embroidery of light.

Thus in patient record did they arrive at the great discovery, fundamental to all later knowledge. Projecting each track upon the chart as it was determined by the well-known stars athwart which it moved, extending each track backward against its direction of motion, it was found that the area of general intersection corresponded most closely with the point in the remoter heavens marked by the star Zeta Leonis. The radiant point had been found and delimited in space. Henceforth this November star shower was to be known as the Leonids, the lion cubs. This was the beginning of the science of the shooting stars, and it dates from 1833, science calmly at work in the tumult of a world turned upside down.

The next preceding shower has an initial importance bearing upon this discovery of the radiant point. In the early morning of November 12th, 1799, at Cumana, Humboldt had witnessed a fire storm in the skies, and with his wide backward gaze he reached the conclusion that these meteors observed a period and that the study of the records of the past could be made to discover the length of the period. Three times in every century the November skies have set the stage for the great pyrotechnics of the heavens.

A great display was recorded when Ibrahim, the second of the Aglabids, lay dying before Cosenza and awaiting the coming of Sheitan to take him to the punishment of his many cruel deeds. All night long the rain of stars, the torrent of meteors, brought terror to the faithful of one faith whose monarch lay dying, terror to the faithful of an older faith cowering behind their city walls. This was the night of October 19th, 902. From this date it is easy to reckon the slow periodic change; the node advances 14½ degrees in 1,000 years. That was 1,000 years ago.

A second thousand years backward into time bounds the history of the lion's cubs as the world knows history. Leverrier has computed that it was no longer ago than 126 A. D. that Uranus exercised its mighty attraction upon a comet errant through outer space, chained it to an elliptical and recurring orbit of thirty-three years about the sun and broke it into a swarm of cosmic gravel.

The word gravel is used advisably, yet it can be no more than an estimate based upon the brief visibility of an object which in its very essence can never become tangible and therefore ponderable. No smallest mass from a periodic meteor shower has ever come to earth in such a way as to be identified beyond all peradventure of doubt. The astronomical records afford but two instances in which objects coming to earth from outer space might be suspected of a common origin with synchronous displays of meteor rains.

The former of these was a bolide which came to earth in France on April 4th, 905, a shower of Lyraids simultaneously attracting to the heavens the wondering gaze of the people of western Europe. Of this hot visitant the Saxon chronicle records that one of the eye witnesses "cast water upon it, which was raised in steam with a great noise of boiling."

The later instance was observed at Mazapil in Mexico during the Andromede rain of November 27th, 1885. That which was described as a ball of fire struck the ground and when cool was found to be a piece of iron weighing eight pounds and containing nodules of graphite. These two bodies came into reach during a display of shooting stars. But they lack observation concerning their radiant point, therefore there is no ground for associating them with the simultaneous phenomenon.

The pea size estimate is generally accepted as the measure of the components of the periodic shower meteors. Only slightly larger is the estimate made by Dr. Johnstone Stoney in his address to the British Association upon the Leonids of 1866.

"The meteors themselves," he said, "are probably little pebbles, the larger about an ounce, or perhaps two ounces, in weight and spaced in the densest part of the swarm at intervals of one or two miles asunder every way. The thickness of the stream is about 100,000 miles, which however is a mere nothing compared with its enormous length. The width is such that the earth when it passes obliquely through the stream is exposed to the downpour of meteors for about five hours."

For the Leonid stream Miss Clerke employs a bijou simile—"a ring with a gem on it." The ring is the long ellipse in which the shower revolves, now close enough to the sun to permit the earth to cross its orbit, again swinging far out beyond Uranus to the limit of planetary space, yet never quite losing its obedience to the sun's reclaiming pull.

Along this long ellipse is spotted a chain of this cosmic gravel, enough to mark its presence every November night when the earth plows us through the orbit. The gem, a brilliant indeed, was the great central agglomeration of the mass which yielded such a terrifying rain in 1833, such a flashing display in 1866, the persisting remnant of the disintegrating comet gone into gravel along its orbit.

That is the explanation now offered for these calendar displays, now generally accepted. Astronomy has computed the elements of each meteoric shower as it recurs. All of them have been found to obey the rules which govern the comets of known periods, those which have been proved to have elliptical orbits, and thus are chained from their first wild flight into regular, though erratic, members of the solar system. In this theory the meteor nucleus represents the disintegration form of a comet, possibly once as brilliant an object as Halley's comet now speeding into view.

At intervals along its orbit each comet runs the risk of several collisions, both on its outward voyage into space and upon its return, to be a spectacle in our heavens. It is merely a matter of the mathematics of orbital revolution of two bodies obeying in different order the same central impulse.

Sooner or later, reckoned in cycles of long ages, the two are destined to struggle for the occupancy of the same spot at the same time. It is the comet which bears the brunt; the earthen pots come not back from the cistern where the iron pot is filling. The comet has been shattered and the meteor shower is its survival. The earth has been seen to tear through such mass as a comet may be considered to possess; it has been seen to disrupt it.

At first in the early existence of this degradation phase the disintegrated cometary nucleus is the brilliant on the ring; at the time appointed for the comet the rain of meteors shows some few of its fragments flashing into fitful brilliance at the outer envelope of our atmosphere. But each pebble that once was comet is a tiny unit of the system; it must obey the fundamental law of revolution; even as the greatest of the planets it is subject in its minuteness to the laws of perturbation, and perturbation acting counter to velocity along the orbit means a drag.

Inevitably the drag dots the orbit with laggard pebbles; in slow lapse of long time the brilliant creates the ring in which it is set. As time goes longer on the ring becomes first complete, then more evenly spaced, until at last the brilliant vanishes, the setting has absorbed the gem.

To the slow and inevitable change is added the suddenness of collision, a brief accomplishment of what would otherwise be more slowly done. As we have already seen, Leverrier found the solar history of the Leonid rain to begin in the capture of a comet accomplished by the enormous influence of remote Uranus in the year 126 of our era. At that or at some later period the parent comet was in collision with some one of the greater planets.

Its substance was rent to pieces and the meteor gem was set upon its orbit. In 1833 and in 1866 the earth tore through the nucleus of the fragments. Some few it burned and destroyed by the friction engendered in its atmosphere; only a few, for the estimate of 240,000 is less than the counting of the veriest pinch of sand.

To countless others it assigned a perturbation, a drag destined to spread them evenly along the orbit. The shower of 1899 showed the loss; it is computed that in less than two centuries the gem will have vanished in the evenly dotted ellipse. It has been figured out that in the point of the comet's orbit which is soon to be crossed there exists such a closeness of distribution of the icy pebbles as possibly to afford this year a considerable display.

This cometary theory of explanation was not reached without a struggle. In the early days of thought, when the earth was the center of revolving pettiness, it was sought to find a telluric origin for these phenomena, not then perceived to be periodic.

Some essayed the proof that the volcanoes which carried ruin to peaceful lands no less bombarded the heavens. The shooting stars were considered to be but the volcanic ejections falling, as fall they must inevitably.

When this theory failed to give satisfaction recourse was had to a theory that in some sudden way the vapors of the upper sky were agglomerated; as soon as they became ponderable they were subject to the forces of gravitation and inevitably fell. But no one was able to account for the power which acted in this sudden creation of ponderable mass from floating gas.

Next the moon was sought out. The telescopes showed pitted mountain peaks, huge craters. At once the idea gained ground that the volcanoes of the satellite were bombarding the parent planet.

The ballistics was computed. It was established that if an object could be ejected from the moon with an initial velocity of 8,000 feet in a second it would reach the earth's atmosphere with a velocity of 35,000 feet. Yet to correspond with the measured velocity at the earth would call for fourteen times the minimum velocity of projection at the lunar surface. No such power could be discovered as active upon the dead surface which we see.

Out in our Southwest remains unsolved the greatest problem, whether of meteorites or rain of shooting stars, a vast cavity for which the explanation has been offered that its rending of the earth's crust marks the impact of some celestial projectile.—New York Sun.

A GAS-ELECTRIC MOTOR CAR.

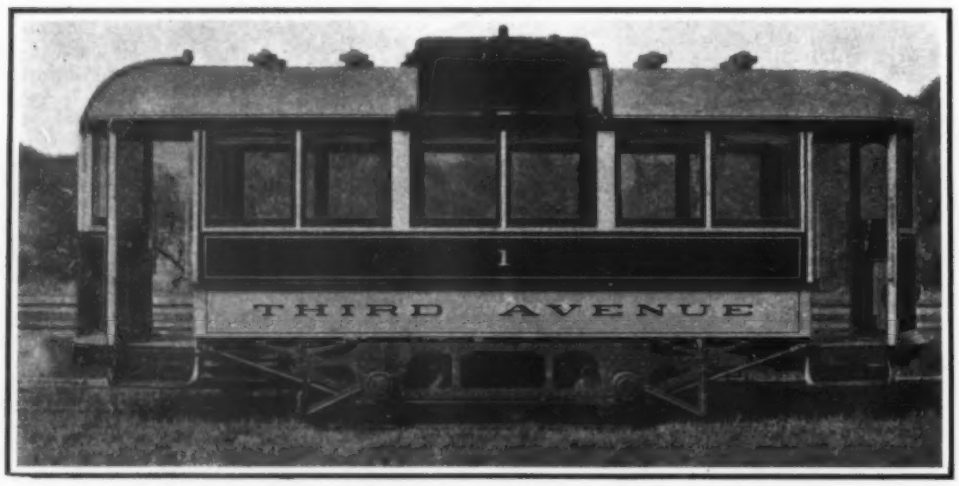
A NEW TYPE OF CAR FOR NEW YORK.

THE General Electric Company has completed the construction of a single-truck car for the Third Avenue Railway Company of New York, which is driven by a totally inclosed gas engine mounted between the axles. As shown in the photograph the car resembles in many respects the short cars on many of our city railroads, and in operation can scarcely be distinguished from an ordinary electric car.

The gas engine has a four-cylinder, four-stroke-cycle engine direct connected to a generator and exciter, and the electrical energy thus developed is transmitted to two railway motors mounted on the axles. The car is operated from either end by an electrical controller in the same manner as a trolley car. The controllers on each platform connect the motors progressively in series and in parallel, and regulate the voltage supplied to the generator, as required by the speed of the car. In this way all mechanical connections between the gas engine and the driving axles are eliminated. The gas engine, provided with automatic centrifugal throttle governor, runs at constant speed regardless of the speed of the car, and thus operates at all times at high efficiency. The operator has no auxiliary levers for controlling the gas engine or the car.

A Bosch low-tension magneto supplies the ignition system, which is of the make-and-break magnet plug type. The engine is started by a crank direct from the magnet.

The exciter referred to above supplies power for the main generator field and for the lighting of the car.



THE GAS-ELECTRIC MOTOR CAR.

The car has no monitor, its roof being dome-shaped with suction ventilators. Water-cooling radiators are placed on the roof over the center of the car and are connected to the water jackets of the cylinders by pipes inclosed within the center posts of the car. The circulation is semi-siphon.

The truck is of special light construction of riveted plate frame, equipped with Hess-Bright ball-bearing journal boxes. The truck frame is supported on coil springs and is steadied by half-elliptic springs at the ends of the truck frame.

The following are some of the general dimensions: Length over all, 28 feet; length of body over end frames, 19 feet; wheel base, 7 feet 6 inches; height, rail to top of roof, 12 feet; width over all, 8 feet; seating capacity, 26; weight complete equipped, 12 tons.

CRANKED AXLES.

At one time New England locomotive builders displayed much fondness for inside cylinders, and Isaac Hinkley, one of the pioneer locomotive builders, expressed regret while on his death-bed for having abandoned inside cylinder engines. In the British Isles inside cylinders are used almost exclusively in spite of the fact that many disastrous accidents have often happened through the breakage of crank axles, which is the weak link in an inside-connected locomotive. When such accidents have happened the railway companies responsible have been denounced by the press and public for their reckless practice in using the dangerous cranked axle, but the storm soon blows over and the crank axle holds its own.

A locomotive crankshaft is an article which must be capable of resisting a curious array of dynamic stresses. The shaft resembles a girder supported at two points and loaded at two other points. It bends under the load, a small degree perhaps, but it bends. Moreover, in the fraction of a second the stresses and deflection are reversed in directions producing the most destructive action that can be imparted to machinery.

Inside cylinders produce a fine, steady running locomotive, and the cylinders set inside the smokebox find a warm nest that reduces the loss from cylinder condensation. These are valuable features, but they are secured at high cost when a broken axle is always a probability to be dealt with. It is fortunate that fashion has not ordained that the enormously powerful locomotives becoming the motive power of American railways should be built with the uncertain element of a cranked axle.—Railway and Locomotive Engineering.

HOW TO CONSTRUCT AN EFFICIENT ELECTROLYTIC RECTIFIER FOR ONE DOLLAR.

By H. T. HEWLETT.

IT does not seem to be generally known by amateur workers, who wish to use direct current, that the alternating "juice" supplied in many of our smaller towns, can be readily and cheaply converted by an electrolytic rectifier. Such an apparatus, sometimes called also a current reorganizer or a nodon valve, is not as efficient as the mercury arc, nor can it well be used on currents of over 220 volts; but it is much cheaper and simpler to construct, and the amateur seldom has occasion to use higher than 110-volt currents. In explaining the rectifier's action, we may liken the alternating current to a series of rising and receding waves of water; the apparatus acts as a check valve, allowing all of the waves to pass, but when they start to recede, the valve closes and prevents them. Thus the current is not changed into a truly continuous, but into a unidirectional pulsating one. It is similar to that supplied by a dynamo fitted with the old Siemens H armature and a two-piece commutator. In its simplest form such a converter consists of an aluminium and a lead plate, immersed in an oxidizing solution. The current passes freely in one direction; but when its direction changes, the metal becomes coated with oxide, thus causing so great a resistance that the flow ceases.

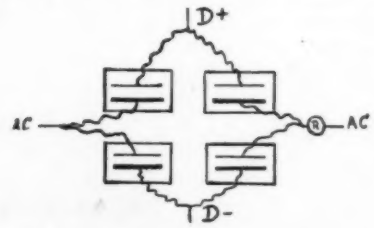
In actual practice, however, it has been found that a single cell is not sufficient, and for the apparatus described here we use four. Procure, therefore, four battery jars and the same number of lead and aluminium plates, as large as will just fit nicely in the jars. The lead should be not less than 3/32 of an inch in thickness, and the aluminium as pure as possible. Fasten the plates to a small piece of wood in a manner similar to the elements of a primary battery, attaching a short piece of copper wire to each. For this purpose binding posts from exhausted dry cells are good, as it is difficult to solder aluminium.

Connect up the plates as shown in the cut, the light lines representing the aluminium plates and the dark ones the lead. Fill up the jars with a saturated solution of ammonium phosphate. Take the direct current from terminals *D+* and *D—*, while the alternating current is fed in at AC^1, and AC^2, using a plug to connect with a lamp socket. It is also necessary to place some resistance at *R*. For this purpose a lamp board is a great convenience, but by having a 16, a 32, a 50, and a 100-candle-power bulb, sufficient flexibility can be obtained for most occasions. Use lamps designed for 20 volts lower than the supply circuit of 110 and higher voltages, to allow for a drop due to the internal resistance of the cells. In order to obtain the best results it is necessary to observe care on several points.

Use only distilled or rain water and add more water occasionally to make up for loss due to evaporation. In case of excessive heating or foaming use larger plates. Both plates slowly oxidize and it is well to scrape the aluminium plate once in a while. The liquid in the jars slowly decomposes, and if not renewed the "valve" no longer closes and prevents the receding current from passing. Its life may be greatly prolonged by pouring a small quantity of blue litmus solution into each jar and frequently adding enough phosphoric acid to turn the solution pink. This is often done when performing experiments of long duration and which cannot be interrupted. But it cannot be continued indefinitely, because excessive waste products finally collect. The total cost of this apparatus does not exceed one dollar.

By using a different electrolyte, the rectifier can be employed on a large range of voltages. For currents of less than 20 volts use dilute sulphuric acid; while for the usual 110-volt current, a saturated solution of ordinary baking soda (sodium bicarbonate), sodium or potassium phosphate or the ammonium phosphate, used above, seem equally good, but for 220 volts use the ammonium phosphate.

The apparatus will pass as high as 7 amperes and may be put to a great variety of uses, replacing about 20 bichromate cells. It has been successfully used for experiments in electrolysis, for charging storage batteries, to run a Ruhmkorff coil, and for many similar purposes too numerous to mention. In a certain few cases, such as experiments in wireless telephony and



telegraphy, the pulsating current may be objectionable, and it sometimes causes small motors to give off a hum. These drawbacks may be overcome by using small storage batteries or ordinary dry cells in the circuit. Thus when the current starts to drop between the pulsations, the batteries begin to feed in, and the current is continuous.—Electrician and Mechanic.

WIRELESS TRANSMISSION OF WEATHER SIGNALS.

THE feasibility of maintaining a regular service of weather indications at sea by means of wireless telegraphy is being discussed in various quarters. Western Europe would derive great benefit from such a system of warnings sent from Atlantic and American stations. The weather in the west of Europe is closely dependent upon barometric depressions, which generally come from the west, and originate either in America or over the Atlantic Ocean. Transatlantic steamers could therefore give valuable warnings several days in advance.

The United States Weather Bureau has been making practical experiments in this matter since 1905, by receiving from many authorized vessels wireless information of meteorological observations made daily at noon (Greenwich time) and transmitting by wireless telegraphy, to ports and vessels, weather forecasts deduced from this information. Discoveries of icebergs, derelicts, etc., are also received and distributed in the same manner. Prof. W. L. Moore, the director of the bureau, is endeavoring to form an international organization on the same basis, and has come to London to assist at a congress formed to discuss the establishment of a general and regular service of weather indications, sent from vessels to other vessels and shore stations. Such a service would give vessels information of the existence and location of storm centers, and of the direction and velocity of their movements. A uniform system of weather signals would be adopted, and every vessel would be required to make meteorological observations at a prescribed hour and to transmit these observations to other vessels and coast stations. These general regulations, together with the requirement that all vessels of a certain tonnage must carry wireless apparatus, would be favorably received by the majority of shipping companies.

SANTOS DUMONT'S LATEST MONOPLANE.

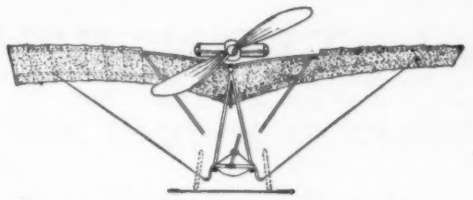
WITH WORKING DRAWINGS OF THE MACHINE AND ALL ITS PARTS.

SOME months ago, Santos Dumont, who keeps his machines at Saint Cyr, and Maurice Guffroy, who is stationed at M. Pelterie's aerodrome at Buc, bet each other a thousand francs that each one would be the first to visit the other by aeroplane. On September 13th, the weather being calm, Santos Dumont undertook to win this bet. In this he was entirely successful, for, starting from Saint Cyr, he flew across the valleys, roads, railroad tracks, and trees at a height of 250 feet to Buc, where he landed some 5 minutes later. The 8 kilometers (4.96 miles) were covered, therefore, at a speed of about 59½ miles an hour, if the times and distance given are correct. Besides making this record flight, Santos Dumont, on the 16th of September, made an official start before a committee of the Aero Club of France and succeeded in getting off the ground after running a distance of 70 meters (229.6 feet) in 6¼ seconds. This excelled the record of 80 meters (262½ feet) made by Glenn H. Curtiss at Brescia, Italy. The following day, September 17th, Santos Dumont made two flights. The first of these, begun at 4:30 P. M., was a circular one of considerable distance across country. The second one, which was started an hour later, was the most remarkable. After flying some distance across country at an elevation of 70 meters Santos Dumont landed in the park of the chateau of Wideville near Davron

SANTOS DUMONT MAKING HIS CROSS-COUNTRY FLIGHT.

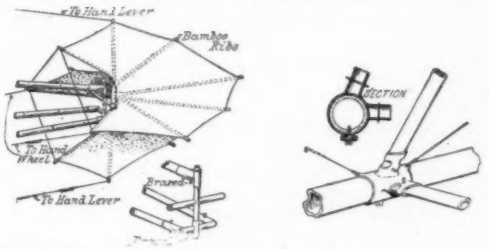
and about 18 miles from Versailles. He dined with Mme. De Galard and returned the next day by automobile to Saint Cyr, carrying the monoplane on the back of his auto. The people who saw him start did not know what had become of him. The following day Santos Dumont made an exhibition flight of five minutes' duration during which he rose to a height of 70 meters and took his hands off the controlling levers while flying, in order to demonstrate the perfect stability of his machine. On September 19th he made two more exhibition flights before 5,000 people, who came out from Paris to see him. One of these flights was from 7 to 8 minutes' duration, and the other one about 3 minutes. The carbureter did not work very well and he was obliged to cut short the second flight. He, however, again demonstrated the stability of his machine by flying with his hands off the levers, and with arms extended he held a handkerchief in each hand to show that he was not controlling the monoplane. After this flight the machine was dismounted and the motor sent to its maker to be overhauled.

The above interesting record of Santos Dumont's No. 20 monoplane makes a detailed description of this machine of great interest; especially is this the case since the daring little Brazilian aviator announced that he would give his patents to the world, so that any one may construct one of these machines without hindrance. They are also to be put on the market in Paris at a price of $1,200 to $1,500. Another reason why this machine is so interesting is that it is the smallest and lightest monoplane which has ever flown with such marked success. Santos Dumont has flown with a similar machine before, but not with the speed and stability which his No. 20 "baby" monoplane has shown. The total weight of this diminutive flyer is but 242 pounds, while the weight of the engine is 110 pounds. The spread of the plane is 18 feet, and the over-all length of the machine is but 20 feet, while the height is but 4 feet 2 inches, or, with the



FRONT VIEW OF MONOPLANE.

Showing wires and lever for warping the rear part of the wings.



DETAILS OF TAIL AND FRAME OF SANTOS DUMONT'S MONOPLANE.

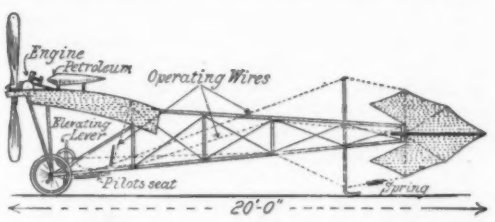
The horizontal and vertical surfaces are hung upon a universal joint which is shown in detail below. The right-hand drawing shows the method of joining the oval tubular braces to the bamboo poles of the main frame.

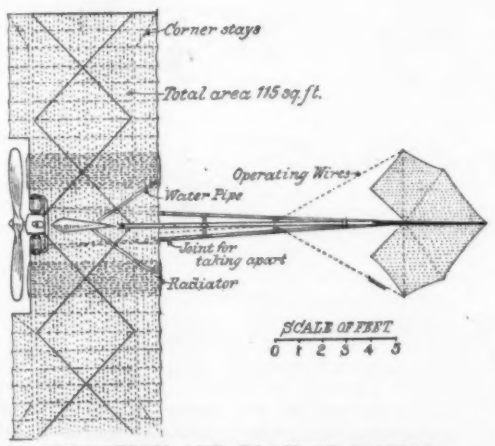
propeller in its vertical position, 7 feet 5 inches over all. The area of the plane is 115 square feet, so that the total weight carried per square foot with Santos Dumont (110 pounds) on board is about 3.6 pounds.

One of the most noticeable features of this monoplane is the use of bamboo for the body frame and also for the frame of the tail. The body frame consists of three stout bamboo poles about 2 inches in diameter at the forward end and tapering to about an inch at the rear. Two of these bamboo poles extend backward and upward at a slight angle from the front wheels, while the third one extends backward and downward at a slight angle from the center point of the plane. These poles are jointed near the rear of the main plane, so that they can be taken apart without difficulty. Brass sockets are used for this purpose. The poles are connected together at intervals of about two feet by inclined uprights of oval section steel tubing. The panels thus formed are all trussed with diagonal piano wires provided with suitable turnbuckles. The lower bamboo poles of the frame terminate at the front axle, upon the upwardly inclined ends of which are mounted on two wheels. Forwardly inclined braces on either side of the wheels extend upward to the front edge of the plane, upon which is mounted the motor. This is of the double-opposed-cylinder type, made by Darracq & Cie. It is a very light motor, having brass water jackets, mechanically operated inlet and exhaust valves in the cylinder heads, and carrying the propeller on the front end of its crankshaft. A gear water pump is mounted on the rear end of an inclined shaft projecting out at the rear. The 2-to-1 gear is on the center of this shaft, and the magneto on its front end. The carbureter is also at the rear of the motor and is supplied from a gasoline tank of torpedo shape placed behind the latter. A larger fuel tank is located back of Santos Dumont's seat. Special radiators of very thin copper tubing ⅛-inch in diameter run from the front to the rear of the main plane on its under side about two feet to the right and to the left of the center line of the machine. The water which passes out of the jackets on their upper sides goes through inclined pipes to a small wedge-shaped tank, through which it descends to the bottom of the radiators at the rear edge of the plane. The pump forces it through these radiators to headers at the front edge of the plane which are connected to the bottom of the water jackets. This

FRONT VIEW OF CENTER OF SANTOS DUMONT'S MONOPLANE.

An excellent idea of the motor, propeller, etc., can be had from this picture. The aviator sits in front of the auxiliary gasoline tank below.





ELEVATION AND PLAN OF SANTOS DUMONT'S No. 20 MONOPLANE.

Note the skid used at the rear instead of a wheel. The rudder-operating wires pass above and below the upright, the lower end of which is curved to form a skid. The lever and hand wheel in front of the seat work the horizontal and vertical planes of the tail respectively.

motor has a bore and stroke of 130 and 120 millimeters (4.118 and 4.724 inches) respectively. It runs at 1,800 revolutions per minute, at which speed the 6½-foot propeller develops a thrust of 242½ pounds when the monoplane is held stationary.

The main plane is built upon four transverse spars —two on each side of the central bamboo—of ash wood set at a slight dihedral angle. These are about 2 inches wide by 1⅛ inch deep a few feet each side of the center of the machine, and they taper down to a scant inch in depth at the center bamboo and at their outer ends, though the width remains the same throughout their entire length. The front spars are about 9 inches back of the front edge of the plane, while the rear ones are about 12 inches forward of the rear edge. The planes are double surfaced of silk, and they are laced above and below the bamboo ribs which run fore and aft beneath the main spars and terminate in a forked clip through which a wire is strung for the purpose of lacing on the silk covering. The angle of greatest incidence of the plane is at the center and diminishes slightly toward the outer ends, while the greatest camber is not as close to the front edge as usual, but is barely in front of the center of the plane. The camber is about four inches in the chord of 6 feet 5 inches. Diagonal guy wires divide the main plane into four panels, as can be seen in the plan view annexed. These wires are placed between the two layers of silk which form the top and bottom surface of the planes. The upper and lower surfaces are also sewed together between the ribs, so that the ribs really run through pockets.

The tail consists of a horizontal and of a vertical surface placed upon a universal joint about 10 feet

back of the rear edge of the main plane. Both of these surfaces are quite flat and are stretched upon bamboo ribs. The horizontal one, which serves to steer the machine in a vertical plane, is 6 feet 5 inches across and 4 feet 9 inches from front to back. The vertical rudder has a similar polygonal shape and the same length from front to back, although its height is considerably less, being only 3 feet 7 inches.

The diagram shows the details of the tail and wires which operate it. The tubular cross connecting the three bamboos of the main frame together at their rear ends swivels in the brazed sockets (attached to the bamboos) for steering right and left, while a pin passing through the hollow cross tube and attached to the horizontal surface allows the whole tail to move up and down around it in order to steer in a vertical plane.

There are three methods of controlling the machine aside from the switch button, which is placed in the end of the horizontal rudder lever. This lever is convenient at the right hand of the aviator, and is pushed or pulled to steer the machine up or down. A small hand wheel at the aviator's left hand turns the vertical rudder to right or left, and a vertical lever projecting upward behind the aviator's back and fitting in a pocket sewn to his jacket warps the rear edge of the plane when it is swung to one side or the other. In this way, the transverse stability can be maintained. All the steering wires have springs interposed, so that they are always held taut. This method of warping the wings of the plane is the same as that used by Bleriot, while the method of accomplishing it by a movement of the aviator's body is that used by Curtiss. The method is the same as that employed by the Wright brothers on their biplane, and which they have covered by their patent.

THE PARIS AVIATION EXHIBITION.—III.*

CONSIDERATIONS REGARDING MOTORS AND THEIR LOCATION.

Concluded from Supplement No. 1766, page 295.

Two points of importance in the construction of the aeroplanes shown, on which there is a good deal of diversity of practice, are the position of the steersman and that of the engine. In the biplane type the steersman almost invariably sits on the lower plane, the engine being also placed between the planes. In the case of the Farman and Wright machines he sits at the extreme front edge of the lower plane with his feet overhanging (Fig. 1). In this case the engine must be either alongside or behind him, the former position being chosen by the Wrights, who drive the propeller by chains, and the latter by Farman, who drives it direct. In the monoplanes the engine is almost invariably placed at the extreme front end of the main backbone, driving the propeller direct, the engine being, therefore, practically on a level with the main plane. In this case there are two distinct positions in which the steersman can be placed, the first being behind the engine and inside the backbone, as Fig. 2, and the second below the main plane, as Fig. 3. The former position is the one chosen in the "Antoinette" and the single-passenger Bleriots, while the latter is adopted in the "Demoiselle." The two-passenger Bleriot also carries the passengers below the planes, but in this case they are farther back, and the engine is placed in front of them, driving the propeller by a chain. The position of the center of gravity of the whole machine with relation to the main planes can probably only be varied within moderate limits, and therefore it seems that, generally speaking, as the engine is moved forward the steersman must be moved back, and *vice versa*. No doubt there is a certain amount of latitude in this respect, as the subsidiary plane which controls the elevation can be made to take a greater or less proportion of the total weight, but the latitude allowed by this in any particular type will be limited.

Apart from structural convenience, the three main factors in the choice of position of the aviator appear to be (1) convenience of driving; (2) comfort; (3) safety in case of accident.

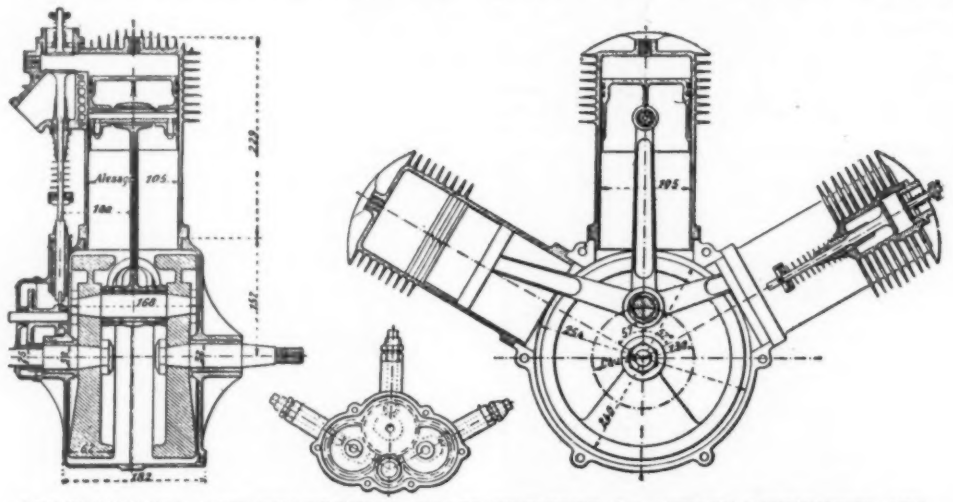
With regard to the first, it would appear, *prima facie*, that it was a considerable advantage not to be too near the front of the machine; i. e., that it would be easier to manage the steering, etc., if there was a good length of the structure in front of the steering position. Those who have done very much steering of boats or motor cars will be well aware that it is in practice a great deal easier to manage them if there is a good deal of their length in front. If, for instance, the wheel of a boat is placed right in the bows, it is not nearly so easy to steer as if the wheel is placed farther back, and in practice it is placed either fairly in the middle of the length or near the stern. Similarly, the steering-seat of a racing motor car is always much nearer the back than the front. It seems likely that in the aeroplane much the same will be found, though this can only be proved by experience.

In the case of the biplane the position at the front of the main plane has not such great disadvantages in this respect as in the case of the monoplane, as there is usually a structure in front carrying the elevation plane.

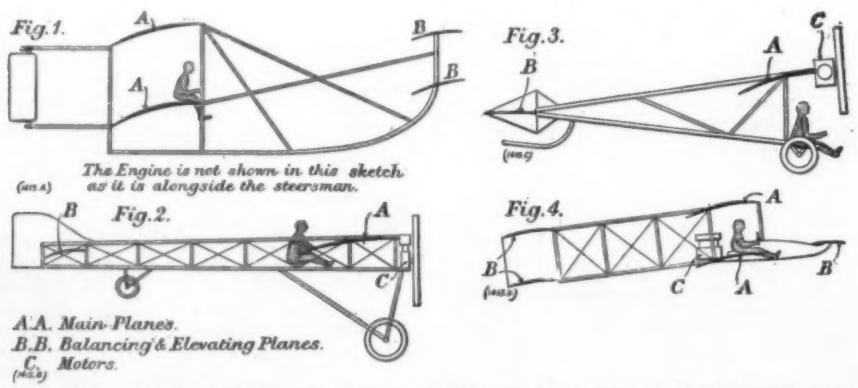
On the other hand, if the steering position is placed very far back, the main planes largely obscure the view downward. In the case of the "Antoinette" the steering position is right behind the main wings, so that a very clear view is obtained downward, but the wings obscure the view below and in front. From the position in the Wright, Farman, and "Demoiselle" machines, on the other hand, the whole of the front is open, and a very clear view obtained. If it were desired to get a better view with a monoplane of the "Antoinette" type than is at present obtained, it seems as if it would be quite easy to leave a small space between the main wings and the body to give it. From the point of view of comfort there can be little doubt that it will be an advantage not to be too far forward. If seated farther back, the steersman is much better protected from cold, which is of some importance, and to many people the feeling of having their feet hanging over nothing will not be comfortable. In the Voisin machine, where the steersman is placed in front of the engine, he is farther back than in some of the biplanes, as Fig. 4, and the part covering his legs is cased in, forming a protection from the wind.

With regard to the matter of safety, the position well behind the engine, and high up, appears to have great advantages. If the engine is behind the steersman, there is always a chance, in case of the machine falling on its head, of the engine coming on the top of the steersman, and this is also true, to a certain extent, when it is above him. It is true, on the other hand, that should the engine catch fire, the position behind it would be very unpleasant; but probably matters can be arranged so that there is no danger of this happening. The very low seat adopted in some of the monoplanes seems as if it would render the landing much more risky than when it is higher up, as, if there is a good deal of the structure between the steersman and the ground, this would break his fall in case of a misjudged landing. The difficulty of landing will be great in the case of a machine which, by reason of its small wing-spread, has to fly fast, and therefore such machines should only be used by the experienced expert. From this point of view it is very doubtful whether the fact that such machines are the cheapest to purchase will be to the advantage of the industry, as it may tempt novices and cause accidents.

In engine construction one of the principal differences of opinion is as to air versus water cooling. The necessity for keeping the cylinder down to a certain temperature is obvious, as the power of an internal-combustion engine depends entirely on the difference of temperature before and after the explosion. Anything which raises the temperature of the charge before explosion therefore diminishes the power of the engine. Should the cylinder be hotter than the incoming gas, the latter will be raised in temperature during suction and compression by the cylinder wall, the extent of this in a given engine depending on the temperature of the cylinder and speed of the engine. The higher the speed the less time the gas is in contact with the cylinder, and therefore the less it is raised in temperature. Hence, with a high engine speed the loss of power from a hot cylinder is less than with a low-speed engine. Strictly speaking, all engines are air-cooled eventually, as the heat transferred to the cooling water is given up to the air by the radiator. If, therefore, we could have an effective surface on the cylinders equal to that of a radiator, the cylinder temperature would be the same. Now the surface of a radiator necessary for keeping the water from boiling is less the greater the speed of the air through it, and therefore there would be theoretically some speed through the air at which the air-cooled cylinder would not get above the temperature for safe working. But, even in racing cars, which go over 70 miles an hour,



LONGITUDINAL AND TRANSVERSE CROSS SECTIONS OF ANZANI 3-CYLINDER AIR-COOLED MOTOR USED ON THE BLERIOT XI. MONOPLANE.



DIAGRAMS SHOWING THE PRINCIPAL TYPES OF MONOPLANES AND BIPLANES.

1. Wright biplane. 2. Bleriot No. 11 monoplane. 3. Santos Dumont's monoplane. 4. Farman and Voisin biplanes.

* Engineering.

the surface of the radiator found necessary is far greater than it would be possible to provide on the cylinders of the engine, and therefore we must conclude that there is no possibility of keeping air-cooled cylinders as cool as water-cooled ones. This means that for the same maintained horse-power the air-cooled engine must be the larger of the two, and the question is whether it is better to have a water-cooled engine with a radiator, or to have an air-cooled engine of somewhat larger dimensions. In the latter case the engine will weigh more, other things being equal, but the weight of the radiator will be saved.

There are two aspects of this question: firstly, which will give the greater power for a given weight; and, secondly, which will make the more reliable engine. With regard to the first it is impossible to dogmatize, as it depends on the relative-sized cylinders required for the air and water cooled engine; and this, again, depends on their arrangement and the speed of the air past them. If we exclude the engine with revolving cylinders, which stands in a class by itself, the type of engine which seems most suited for air-cooling is that in which a moderate number of cylinders are grouped radially round the crank-case, as the "Anzani." In this case, if the propeller is mounted on the engine shaft, the draft from it blows directly on all the cylinders, and should keep them moderately cool. Even then, however, it seems doubtful whether the weight saved by having no radiator would compensate for the loss of power from heating. A point to be considered is that there seems to be a limit to the size which can be air-cooled, owing to the fact that the contents of a cylinder increase as the cube of the dimensions, while the area of radiation only increases as the square, and therefore to get high powers many cylinders must be employed. If these are all grouped above the crank-case, as appears necessary for lubrication, they must be very close together, and this may very seriously interfere with the cooling. It is noticeable that while the one-seated Bleriot is fitted with an air-cooled motor, the more powerful two-seated one is fitted with a water-cooled one.

Ingenious as many of these radial engines are, there are difficulties in balancing, lubrication, etc., and many people prefer the ordinary vertical four-cylinder or diagonal eight-cylinder engine, and in these, if air-cooled, the cylinders can only be kept cool by a powerful fan, as the front cylinder shields the others from the wind. This fan and casing will probably weigh as much as a suitable radiator, and even then will not keep the cylinders so cool.

With regard to the question of reliability there is no doubt that it is a great advantage to do away with the water pump and radiator, which are always a possible source of trouble. Still, these have been made perfectly reliable on cars, and although they may have to be lighter in an aeroplane than in a car, there should be no reason for their giving any more trouble. On the other hand, in the air-cooled engine it is probable that there will be more trouble with the valves, sparking plugs, ignition, etc., as these all have to work at a much higher temperature.

It will thus be seen that the question of air versus water cooling is not one which can be dealt with by itself, but involves, and is dependent on, other structural points in the engine; this makes it the more difficult to forecast which system is likely to come into most general use in the future. The balance of opinion among the aeroplane exhibitors at the show is distinctly in favor of the water cooling, as there are far more water-cooled than air-cooled engines fitted to aeroplanes, and some of the engine builders who have been most successful with their air-cooled engines are now introducing water-cooled ones. So far as previous experience goes this would seem to be right, as for motor cars the water cooling has become practically universal.

In the motor cycle, it is true, air-cooling is also universal; but here the power required is very small, and it is usual to fit an engine of such size that it only works at full power for very short periods going up steep hills, and has therefore many chances of cooling the cylinder when running. It is well known that if a bicycle type air-cooled engine is fitted to a tri-car and provided with several speeds, so that it can be kept working at something like full power, it is not at all satisfactory, and most makers of such vehicles have had to water-cool their engines. Further, air-cooled motor cycle engines are, as a whole, far less reliable than the water-cooled motor-car engines.

The essential advantages which the air-cooled aeroplane engine has over the motor cycle or car engine are: 1. That the air cooling is more effective, especially when the propeller is direct coupled. 2. That it always runs very fast. 3. That at present there is no attempt at silencing. The latter may have a very great influence on the question. It is well known that the more rapidly the exhaust gas is got out of the cylinder the easier it is to keep it cool. At present most aeroplane engines have an absolutely free exhaust, and many have a row of holes in the cylinder uncovered by the piston at the bottom of the stroke to assist this. The noise the engines make is deafening, and it is hardly likely that such arrangements will stay in permanent use. Fitting a silencer to an air-cooled engine may, therefore, considerably interfere with both the power and reliability, while the same result will not follow wtih the water-cooled motor to any great extent.

THE ICE AGE.

ASTRONOMICAL EXPLANATIONS.

BY DR. N. HERZ.

SINCE the discovery of the peculiar exotic bowlders, covered with grooves and scratches, which are known as erratic blocks and are regarded as evidences of past glaciation, it has been learned that this glaciation was a general phenomenon, affecting a large part of the earth's surface. The Alpine glaciers once extended beyond the Danube and the Po; the Scandinavian glaciers covered the whole of England and Germany and filled the North Sea, the Baltic, and the Irish Channel; North America, down to the 37th degree of north latitude, was buried in ice, and traces of glaciation, or of any ice age, are found in many parts of the southern hemisphere.

Various theories have been advanced in explanation of this remarkable phenomenon. The view, expressed by many geologists and geographers, that the glaciation of the ice age was caused by a general lowering of temperature and increase of precipitation, can hardly be regarded as an explanation, for it does not account for the existence of these assumed causes. The hypotheses of change in the diathermancy of the atmosphere, due to an increased proportion of carbon dioxide, change in solar radiation, etc., will not bear critical analysis.

Hence we are led to seek the cause of the ice age in the influence of some element of the earth's motion. The line of the apsides of the earth's orbit, drawn from its perihelion to its aphelion, is not invariable, but rotates slowly in space. In consequence of this motion our summer and the winter of the southern hemisphere, which now take place when the earth is at or near its greatest distance from the sun, will, about 10,000 years hence, occur when the earth is at or near its least distance from the sun, and any excess of solar heat that is now received by one hemisphere will then be received by the other. Mathematical analysis shows that such excess, due to decreased distance from the sun, is compensated by the more rapid passage of the earth through the hotter part of its orbit, but in this calculation no regard is given to the fact that in the complete cycle of changes of water (evaporation and condensation) there is a net loss of heat, in consequence of the dissipation of the heat set free in condensation, and that this loss increases with the difference between the quantities of heat received in summer and in winter.

Furthermore, the eccentricity or ellipticity of the earth's orbit is subject to variations, which may increase it to more than four times its present value. The obliquity of the ecliptic, or the angle between the plane of the earth's orbit and the plane of its equator, upon which the change of seasons depends, is likewise variable and may become 1½ degrees greater or less than its present value. Great climatic changes may be produced by the combined operation of these factors, but they do not give a perfectly satisfactory solution of the problem of the ice age.

All of these variations, or perturbations, are caused by the mutual attraction of the moving planets, but there are other variations which depend upon the position of the axis of rotation in the mass of the earth. If the earth were a perfect sphere, or a perfectly symmetrical spheroid, it would rotate like a symmetrically constructed top. The earth, however, is not perfectly symmetrical, or rather, its axis of rotation does not coincide with its axis of symmetry.

If a straight wire is thrust through the center of an orange (supposed to be perfectly symmetrical) at a slight inclination to the axis of symmetry, and the orange is caused to rotate with the wire as its axis of rotation, the wire, if held in a fixed position, will be subjected to a transverse stress. If only one point of the wire is fixed the rotation will no longer be steady, but the axis of rotation will deviate from its original position. If the wire is entirely free it will not continue to be the axis of rotation, but the latter will move with reference to the orange. This is the condition of the earth. The axis of rotation and, with it, the poles and the equator are continually changing their positions so that, at every point of the surface, the latitude and the altitude of the pole are continually varying. The axis of rotation moves, not only relatively to the mass of the earth, but also absolutely, in space. This motion causes a variation in the obliquity of the ecliptic, to a maximum extent equal to four times the angle between the axes of rotation and symmetry. On the other hand, the motion of the axis of rotation in space affects its position in the earth, until a state of equilibrium is attained, in which the two axes move, absolutely and relatively, in a definite and calculable manner.

The flattening, or oblateness, of the earth has a strong influence on these movements. A decrease in oblateness would greatly increase the movements and would affect the position of the axis more strongly than the planetary perturbations mentioned above. The oblateness, however, is dependent upon the velocity of rotation and the accumulation of matter at the poles. If, in early geological periods, extending over hundreds of thousands of years, the velocity of rotation was much smaller than now, the obliquity of the ecliptic may also have been very different from its present value.

Suppose a perfectly spherical earth to have become, under the influence of its rotation and the tides caused by the attraction of the moon and sun, very slightly oblate in such a manner that the axis of symmetry formed a small angle with the axis of rotation. Then the displacements above described might attain enormous values and a very long period of time would be required to bring about a condition of stable equilibrium by means of the gradual increase in oblateness. In such a period, in which the velocity of rotation, which is continually increased by the contraction of the earth, was smaller, and the axes of rotation and symmetry were more widely divergent than at present, occurred the changes in the obliquity of the ecliptic which caused the great changes in climate represented by the ice ages and the warm intergiacial periods. The glaciation would favor its own development, because the accumulation of ice at the poles would be equivalent to a decrease in oblateness, which would intensify the phenomena until its effect was counterbalanced by the increase in velocity of rotation.

Geologists speak of an ice age, or ice ages, occurring during the diluvial or Quaternary period, and also of earlier ice ages, but the evidence for the existence of the earlier ice ages, with the possible exception of the Permian period, will not bear critical examination. Hence in forming a theory of ice ages only those of the diluvial period need be considered. Many writers have expressed doubt that changes in oblateness could have occurred when the earth was so far solidified, but even a ball of steel of the size of the earth would yield perceptibly to the action of centrifugal force. All the calculations which give the earth a rigidity as high as that of steel are based upon the erroneous assumption that the great pressure existing in the interior of the earth (the pressure at the earth's center is computed to be about 3¼ million atmospheres) is a true measure of the rigidity of the earth. This is as incorrect as an assumption that the pressure of 800 atmospheres which exists at the sea bottom, 5 miles below the surface, is a true measure of the rigidity of the water at that point. In either case the pressure is the hydrostatic pressure due to the weight of the mass above, and the comparatively very thin solid crust of the earth is as susceptible to deformation by centrifugal force as a shell of solid elastic material 16 inches in diameter and 1/30 inch thick, filled with water, would be.

But, in the course of ages, the oblateness has been greatly increased and the axes of symmetry and of rotation have been brought nearly into coincidence, producing a state of equilibrium in which a recurrence of the ice age appears impossible.—Umschau.

ENGINEERING NOTES.

Titanium is being used extensively in the steel rail industry in the United States. Its effect on the steel is very similar to that of vanadium, increasing its ability to resist wear. It is introduced into the steel in the form of ferro-titanium, an alloy containing from 12 to 15 per cent of metallic titanium, the balance being iron.

It is estimated that in the proposed new subway system for New York city a total of more than 100,000 tons of structural steel and steel rails will be required. This will involve an expenditure of upward of $2,000,000 for the steel alone. The new subway will probably require 1,200 cars, which will take 18,000 tons of steel of various shapes, estimated to cost at the mills $550,000.

It is announced that, commencing with November 1st, 773 engines on the Austrian State Railways will use liquid fuel and probably in a short time liquid fuel will also be introduced on all the mountain railways, especially on the lines of Bregeuz, Trieste, and Pontebu. The reasons assigned for the change are that the supply of coal to these lines is a very expensive item, and the damp atmosphere of the mountainous districts considerably lowers the calorific power of coal, the tunnels being soon destroyed by the smoke and gases produced, while the possibility of making an agreeable smokeless journey into these districts, it is hoped, will attract more tourists from abroad, and thus indirectly raise the profits of the state.

In a paper before the South Wales Institute of Engineers, Mr. C. B. Chartres proposed that a turbo-compressor should deliver the air to existing reciprocating compressors at about 15 pounds per square inch, and thus double the capacity of the compressor plant. This proposal is specially intended for collieries where low-pressure turbines can often be put down to work with the exhaust steam from the winding and auxiliary engines. It is well known that turbo-compressors are inefficient for high compressions, but this defect is not very marked at low pressures, and is offset by advantages in the form of small size and simplicity; and also, in some instances, of first cost.

In a paper read before the American Society for Testing Materials, Mr. Robert Job describes a simple test of the value of lubricating oils under service conditions. He found that when heated to a temperature of 450 deg. F. the oils which had given bad results showed a very marked darkening of color, while those which had proved satisfactory showed very little change. Another experimenter, Mr. E. Camerman, of the Belgian State Railways, has devised a test of oils for lubricating engine cylinders. By treating the oil to 400 deg. F. for six hours, it is possible to determine the percentage of oil available for lubrication after allowing for that which escapes with the steam. This varies from a very low figure to as much as 60 per cent.

In a paper read to the Ontario Association of Architects, Mr. Walter J. Francis points out that ferro-concrete buildings possess remarkable rigidity and capacity for acting as a unit. In proof of this the author cited the well-known case of a Hennebique coal bunker in France, where one of the main columns was accidently smashed by a derailed locomotive, but without causing the collapse of the bunker with its thousands of tons of coal. He mentioned also some grain warehouses in Tunis, which settled about 25 deg. out of plumb through the escape of quicksand under the foundations. By loading the elevated side and excavating beneath the footings these buildings were brought back to the vertical without developing a crack in the structures. Similar treatment would obviously be impossible with any other material or method of construction.

The folly of subjecting hollow metal articles to the action of heat without first carefully ascertaining that they contain no water, states the Vulcan, is again illustrated in the case of an explosion which recently occurred at a railway works at Ludgershall. In this case the piston had been removed from a locomotive in order to put in a new piston-rod. To do this it was necessary to take off the piston head. This could not be done cold, so it was placed near a fire on the forge in order to warm it. After being in this position about eight minutes the piston head exploded, with the result that three men were injured by the flying fragments, one so severely that he subsequently died. The piston head, which was constructed of cast iron, was 13 inches diameter by 4 inches thick and there was a cavity in the head on either side of the rod. At the inquest which was subsequently held, a foreman fitter employed at the works stated that "it was the usual thing when taking off the head of a piston to warm it at the fire." Such a proceeding is a dangerous one, as is evident from the results in the present case. All hollow metal articles that have to be heated should have one or more holes drilled in them so as to allow of any water being drained away. The adoption of this simple precaution would have prevented many similar accidents.

ELECTRICAL NOTES.

The Electrical World reports that Prof. R. A. Fessenden has recently submitted a proposition to the United States Navy Department for the equipment, experimentally, of a war vessel with turbo-electric drive. Prof. Fessenden's plan is to use steam turbine three-phase generators, with induction motors on the propeller shafts. He claims that higher power can be obtained with less weight under this system than with any other. The Navy Department has as yet made no decision as to whether it will make the experiment.

The latest innovation in wireless telegraphy is the construction of an underground station in Paris. It is being erected in the Champ de Mars, and will probably be open for use next month. The station will be fitted up on the latest approved lines, and comprise a machine room, a transmitting pole, and accommodation for the officials. By the introduction of a 100-horse-power engine it is hoped that messages may be exchanged with places about 5,000 miles distant. The result of the experiment will be awaited with much interest.

Electric current may leak to earth from any part of a system through (*a*) the insulation resistance of that part of the system, (*b*) the capacity to earth. In direct-current systems we have only to consider (*a*), but in alternating-current systems a capacity current is always flowing to earth from all parts of the system, and in the case of extra high-tension generators and cable networks the capacity current through the insulation of the winding and the dielectric of the cable may be considerable. Inductive leakage paths do not naturally occur, but they may sometimes be considered, since their presence may be beneficial, and they may be introduced artificially.

According to the Electrical Review and Western Electrician, steadily and surely the electrical zone of the New York Central & Hudson River Railway is reaching out toward Fishkill Landing. So steadily is the extension of the zone going on that to reach these villages is now but a step. Croton, about 25 miles south, is already in the zone, and Peekskill, Cold Spring, and Fishkill Landing will be included when the next step northward is taken. Recently the big power plant at Glenwood, near Peekskill, was put in operation. This plant gives the New York Central a power house which will supply power sufficient to run the cars from New York to Croton-on-Hudson. A similar plant is to be erected either at Fishkill Landing or Poughkeepsie. Level crossings are to be abolished within the zone.

It will be useful, states the Electrical Engineer, to give a rule whereby a decision can be arrived at when confronted with the choice between aluminium and copper as a conductor. It is well known that copper is the better conductor for the same size of wire, while aluminium is the better for the same weight, as the difference between the specific gravities of the two metals is so great that an aluminium conductor may exceed a copper conductor sufficiently in cross section to give it the same conductivity and yet be still much lighter than its copper equivalent. It is remarkable, too, that when a copper and aluminium wire have equal conductivity for electricity they have practically the same tensile strength. In other words, the conductivity of aluminium bears the same ratio to that of copper as its tensile strength bears to that of copper. Hence, the question of strength may be disregarded in making the rule. This is that the cost for mere wiring will be the same whether copper or aluminium is used, where the price of the former is to that of the latter as 13 to 25. Obviously if the quotient of aluminium price by copper price is less than 25/13, the aluminium has the advantage, and *vice versa*.

A curious accident, illustrating the trouble which might arise from using tramway standards as stay poles, is described in the National Telephone Journal by Mr. E. Harper, local manager N. T. C., Bournemouth. Six or seven years ago, when the electric tramways were constructed, a small route, carrying a few wires, was placed underground where it crossed the tramways, the cable terminating on the poles at either side of the road. Permission was given in one case for the back stay to be stayed back to the nearest tramway standard, which happened to be in the direct line of pull. Recently the trolley arm of a car jumped the trolley wire, and the driver pulled up at a point which caused the metal end of the trolley arm to connect the live wire with the trolley arm supporting it on the standard to which the stay was attached. This standard was not apparently connected to earth beyond the connection it obtained through being set in cement in the ground. A portion of the tramway current passed along the stay, which was touching the pot-head at the top of the pole, and thus found its way to earth along the lead sheathing of the cable, burning a hole about 2 inches long in the cable sheathing. Mr. Harper explains that, in order to avoid further trouble, one of the tramway authority's strain insulators has been inserted in the stay wire.

TRADE NOTES AND FORMULÆ.

Sinodor, used for removing bad smell and for disinfection, is prepared by heating neutral acetate of magnesia and oxide of magnesia, until a perfect hydrate is obtained and until the mixture is transformed into a slimy mass. It consists of basic acetate of magnesia, with an excess of hydrate of magnesia.

Steel Composition.—60 parts steel shavings, 22.5 parts copper, 20 parts quicksilver, 15 parts tin, 7.5 parts lead, and 15 parts of zinc, are gradually introduced into 860 parts of nitric acid. The reddish brown paste is dried and then melted with twenty times its weight of zinc, the mass being cast into bars. After cooling, the alloy is again melted, with a suitable addition of tin and antimony, according as it is required to be harder or softer.

Smitter-Lénian metal is a composition of 720 parts of crude copper, 125 parts nickel, 10 parts bismuth, 95 parts zinc, 20 parts of tin, and 20 parts of hammered iron. The proportions may be varied, according to the purpose for which it is to be used. First the copper, iron, and nickel, then the bismuth are melted and the mixture poured out, the whole is then melted again, the tin added and then poured into molds. The composition is white, easily wrought or melted, and does not oxidize.

Styresine (enveloping medium for microscopic preparations).—Solid storax dissolved in about five times its weight of coal-tar benzole and then, stirring in the meantime, petroleum benzine is added. This first precipitates the resin, as a brownish black mass. The addition of benzine is interrupted as soon as the fluid assumes a Rhine wine color; it is allowed to stand quiet, is filtered and the solvent distilled off. A substance remains that is faultless as an enveloping medium.

Steel Bronze, by Bonedin and Ptousard.—An alloy of copper, possibly zinc and ferromanganese, with 45 to 80 per cent of manganese. The proportions to be used are as follows: I. For an alloy to replace German silver; 60 parts of copper, 60 parts of ferro-manganese, with 70 to 80 per cent of manganese, and 15 parts of zinc. II. For a Soft Red Alloy: 80 parts of copper, 20 parts of ferro-manganese with 50 per cent of manganese. III. Bronze for Bearings, Faucets, and Valves: 60 parts of copper, 40 parts of ferro-manganese, with 60 per cent of manganese, and 10 parts of zinc.

Strychnine Wheat for Destroying Mice.—Dissolve, warm, in a clean copper kettle that will conveniently contain the wheat to be poisoned, 1 part strychninum nitricum in 80 parts of water, slightly colored with fuchsine. Pour 600 parts of clean, plump-kerneled wheat into the kettle and work it over with a suitable instrument, so that all the grains are uniformly wetted with the solution. Under the influence of moderate heat, stirring continuously, the wheat is desiccated, but not allowed to become perfectly dry. It is then soaked in a dish, stirring constantly, with a saccharine solution, prepared by dissolving 1 part of saccharine in 100 parts of water, adding a trace of bicarbonate of sodium. Of this wheat, small quantities are scattered in the runs of the mice, so that it is concealed as much as possible from birds, a dry day being selected for this purpose.

Sidarizing is a wood impregnating process which has an advantage over other methods in that it imparts absolutely no odor to the wood, does not change its color, and is cheap. The wood is first completely saturated in a hot solution of iron salt, then dried again and placed in a hot bath of water glass. In this bath a chemical change is effected. The water glass solution forms, with the iron salt solution that has previously penetrated into the wood, an iron silicate, in the outer strata of the wood, that is absolutely insoluble in water. This insoluble combination is a perfectly passive substance, which forms, as it were, an armor to the wood saturated with iron salt and protects it from decomposition. The salt that fills the wood cells of the entire section prevents, for a long time, the occurrence of rot in the wood. The process is employed for the better preservation of soft wood, such as grape-vine poles and other stalks, cellar beams, etc.

TABLE OF CONTENTS.

PAGE

I. AERONAUTICS.—Accidents in Aerial Navigation and How to Meet Them..... 311
Santos Dumont's Latest Monoplane and its Performances.—5 illustrations..... 317
The Paris Aviation Exhibition.—III..... 318

II. ASTRONOMY.—The Leonid Shower..... 315

III. AUTOMOBILES.—The Making of Automobile Tires.—By SNOWDEN B. REDFIELD.—5 illustrations..... 312

IV. CHEMISTRY.—Utilization of Atmospheric Nitrogen.—By A. BERNTHSEN..... 306

V. ELECTRICITY.—Electrical Notes..... 320

VI. ENGINEERING.—The Schneider Torpedo-testing Station..... 308
A Gas-electric Car for the Third Avenue Railway Company, New York City.—1 illustration..... 316
Engineering Notes..... 320

VII. GEOLOGY.—The Ice Age.—By Dr. N. HERZ..... 319

VIII. TECHNOLOGY.—The Maratta System of Color..... 311
Trade Notes and Formulæ..... 320